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ON THE DEVELOPMENT AND DISTRIBUTION OF THE YOUNG STAGES OF KRILL (*EUPHAUSIA SUPERBA*)

By

F. C. FRASER, B.Sc.

Department of Zoology, British Museum (Natural History)

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ON THE DEVELOPMENT AND DISTRIBUTION OF THE YOUNG STAGES OF KRILL (*EUPHAUSIA SUPERBA*)

By F. C. Fraser, B.Sc.
Department of Zoology, British Museum (Natural History)

(Text-figs. 1–76)

INTRODUCTION

This report deals with the development of *Euphausia superba* during the period covered by the first fifteen months of its growth. The distribution of this young euphausian with reference to locality of occurrence, time of occurrence and vertical position is also discussed. It has been possible to come to certain conclusions regarding the life history of the animal, but it is felt that there are many points mentioned upon which more research will be required in order to understand their proper significance. It is hoped, however, that the results set down here will be useful in future analyses of *E. superba* material, especially in connection with the very large collections made by the vessels of the Discovery Committee, and that in this way they may help in the final elucidation of the biology of this animal which is such an important constituent of the antarctic fauna.

In a report to the Discovery Committee in 1930, Dr J. F. G. Wheeler demonstrated that there is a two-year developmental period in *E. superba* as opposed to a one-year period in other euphausians whose life history is known. He measured krill from the stomachs of whales throughout a whaling season, and from the analyses of length frequencies was able to distinguish the two-year groups. Dr Johan T. Ruud in 1932 gave the first published account of this phenomenon.

SOURCES OF MATERIAL

The stations mentioned below, from which plankton samples were examined, are nearly all located in the Falkland Islands sector of the Antarctic. The area round South Georgia was concentrated upon in the earlier stages of the investigations, for at that time ice-edge whale fishing was in its infancy and South Georgia was one of the chief centres of the industry. In addition to observations in the South Georgia area many were made in the Bransfield Strait and on lines of stations in the Scotia Sea. It is perhaps unfortunate that the main source of the data presented is thus in a portion of the Antarctic where hydrographic and bathymetric conditions are so very highly specialized. The great ridge of the Scotia Arc, the proximity of Graham Land to the southern end of South America, and the system of currents associated with the Weddell Sea, all contribute to the production of a complex the like of which is encountered in no other region of the Antarctic.

Apart from the stations in the area of the Dependencies of the Falkland Islands, much valuable material was obtained from a series of ice-edge stations extending from eastwards of Bouvet Island to South Georgia: also from stations in the Bellingshausen Sea and from stations made during the first circumpolar cruise of the R.R.S. 'Discovery II' in 1931. Respecting the last series of stations I am indebted to Mr D. Dilwyn John, who was senior scientific officer on the ship at that time, for examining the plankton samples and sending me the young euphausians. I have also drawn very greatly on the information contained in his reports to the Discovery Committee relating to this circumpolar cruise.

A list of the samples in which eggs or young *E. superba* were obtained is given in Table I. The 70-cm. nets yielded the main supply of younger developmental stages, the 1-m. oblique and horizontal nets older larvae and adolescents. The 1-m. oblique and horizontal hauls of the circumpolar cruise were at stations most of which were made during the southern winter. Both in time distribution and in the development of the *E. superba* recorded, the results of the circumpolar cruise form a convenient link between the main body of 70-cm. net results and those of the 1-m. nets.

The plankton samples of the circumpolar cruise were examined by John and only the picked out krill was dealt with by the writer. John's search for *E. superba* covered all stations made between the Antarctic convergence and the ice-edge.

The positions of all stations from which samples were examined are marked on the maps showing distribution, and indication is provided of the presence or absence of krill.

METHODS

A full description of the plankton nets used in obtaining the samples is given in Vol. I of the *Discovery Reports* (Kemp, Hardy and Mackintosh, 1929) and it is therefore unnecessary to recapitulate it here. The whole catch was examined in the small samples and a portion of the whole was used when very large amounts of plankton were taken. In the search for eggs, Nauplii and Metanauplii the macroplankton was picked out and the residue inspected under a binocular microscope. The Calyptopis and Furcilia stages are sufficiently distinctive to enable them to be identified by eye alone. Drawings of appendages were made from unstained material with the aid of a camera lucida.

For the measurement of the larvae two scales were used of which the smaller, having 62 divisions to 1 mm., was employed for eggs and small larvae and the larger, having 24 divisions to 1 mm., for more advanced stages of development. In analyses where actual length in millimetres is not important, results have been classified primarily according to the original units of measurement. The corresponding dimensions in millimetres have been added.

In order to measure the larvae as speedily as possible a shallow trough, having the two long sides at an acute angle, was constructed by cementing strips of glass on a

Table I. *Stations at which* Euphausia superba *was taken*

Station	Position	Date	Net	Depth m.	Time	
					Shot	Hauled
	R.R.S. 'Discovery'	1927				
161	57° 2′ 20″ S, 46° 43′ 30″ W	14. ii	N 70 V	100–50	0905	—
				250–100	—	1100
167	60° 50′ 30″ S, 46° 15′ W	20. ii	N 70 V	250–100	1045	1130
169	60° 48′ 50″ S, 51° 00′ 20″ W	22. ii	N 70 V	500–250	0905	—
				750–500	—	1210
171	62° 07′ S, 57° 03′ W	25. ii	N 70 V	250–100	0905	1100
187	64° 48′ 30″ S, 63° 31′ 30″ W	18. iii	N 70 V	100–50	0945	1020
193	63° 24′ S, 61° 33′ W	28. iii	N 70 V	500–250	1100	—
				750–500	—	1240
194	62° 57′ 30″ S, 60° 22′ W	28. iii	N 70 V	50–0	2100	—
				100–50		
				250–100		
				500–250	—	2220
196	62° 17′ 30″ S, 58° 21′ W	3. iv	N 70 V	50–0	1055	1240
197	62° 27′ S, 58° 11′ 30″ W	3. iv	N 70 V	50–0	1620	—
				100–50		
				750–500		
				1000–750	—	1805
198	62° 38′ S, 58° 04′ W	3–4. iv	N 70 V	50–0	2220	—
				100–50		
				750–500		
				1000–750	—	0042
199	62° 49′ S, 57° 56′ 30″ W	4. iv	N 70 V	50–0	0900	—
				250–100		
				500–250		
				700–500	—	1030
200	62° 59′ 30″ S, 57° 49′ W	4. iv	N 70 V	300–250	1445	1545
201	63° 00′ 30″ S, 59° 06′ 30″ W	5. iv	N 70 V	50–0	0820	—
				250–100	—	0910
202	62° 48′ S, 60° 05′ W	5. iv	N 70 V	50–0	1720	—
				500–250	—	1915
203	62° 56′ S, 59° 50′ W	5–6. iv	N 70 V	50–0	2240	—
				100–50		
				250–100	—	0030
204	63° 05′ S, 59° 42′ W	6. iv	N 70 V	500–250	0800	—
					—	0907
205	63° 14′ S, 59° 34′ W	6. iv	N 70 V	225–100	1200	1217
206	63° 26′ S, 59° 28′ W	6. iv	N 70 V	250–100	1545	1615
209	Port Foster, Deception I., S. Shetlands	14. iv	N 70 V	150–100	0900	0940
	R.R.S. 'Discovery II'	1930				
300	52° 25′ 30″ S, 37° 14′ W	20. i	N 70 V	500–250	1730	2036
302	52° 46′ 30″ S, 37° 12′ W	21. i	N 70 V	250–100	0415	—
				500–250	—	0648
303	53° 00′ S, 37° 11′ W	21. i	N 70 V	500–250	1048	—
				750–500	—	1250

In the column headed "Net", N 70 is the 70-cm. net, N 100 the 1-m. net, and TYF the 2-m. net with stramin bag. B = hauled obliquely, H = hauled horizontally, V = hauled vertically.

Table I (*cont.*)

Station	Position	Date	Net	Depth m.	Time	
					Shot	Hauled
		1930				
304	53° 06′ S, 37° 14′ W	21. i	N 70 V	500–250	1555	1823
305	53° 17′ S, 37° 10′ W	21–22. i	N 70 V	100–50	2130	—
				250–100		
				500–250	—	2353
312	53° 39′ 45″ S, 35° 37′ 30″ W	24–25. i	N 70 V	220–100	2350	0345
313	53° 32′ 30″ S, 35° 24′ 30″ W	25. i	N 70 V	250–100	0530	—
				750–500	—	0720
319	53° 37′ S, 38° 39′ 30″ W to	29–30. i	N 70 V	50–0	2253	—
	53° 33′ 30″ S, 38° 37′ W			100–50		
				250–100		
				1000–750	—	0116
320	53° 10′ 30″ S, 39° 44′ 30″ W	30. i	N 70 V	250–100	1610	—
				500–250	—	1806
321	53° 17′ S, 39° 31′ W	30–31. i	N 70 V	100–50	2119	—
				1000–750	—	2352
323	53° 28′ S, 38° 55′ W to	31. i	N 70 V	500–250	1105	—
	53° 29′ S, 38° 55′ 30″ W			1000–750	—	1247
324	54° 56′ S, 39° 57′ W to	1. ii	N 70 V	250–100	0855	—
	54° 56′ S, 40° 01′ W			500–250	—	1215
332	54° 44′ 30″ S, 39° 09′ W	2–3. ii	N 70 V	250–100	2300	2330
335	55° 33′ S, 36° 49′ 30″ W to	4–5. ii	N 70 V	50–0	2203	0315
	55° 31′ 30″ S, 36° 49′ 30″ W					
337	55° 09′ S, 36° 48′ W	5. ii	N 70 V	250–100	1223	1440
338	55° 00′ 30″ S, 36° 46′ W	5. ii	N 70 V	225–100	1614	1646
342	55° 47′ S, 34° 11′ W	7. ii	N 70 V	500–250	1210	1505
343	55° 40′ S, 34° 23′ W	7. ii	N 70 V	250–100	1724	1850
344	50° 33′ S, 34° 35′ 30″ W to	7–8. ii	N 70 V	100–50	2135	—
	55° 29′ 30″ S, 34° 34′ W				—	2350
345	55° 20′ S, 34° 47′ 30″ W	8. ii	N 70 V	180–100	1155	1257
353	54° 17′ 30″ S, 35° 06′ W	9. ii	N 70 V	250–100	1216	1405
354	54° 15′ 30″ S, 34° 47′ 30″ W to	9. ii	N 70 V	500–250	1548	—
	54° 13′ 15″ S, 34° 46′ W				—	1800
356	54° 11′ S, 33° 49′ W to	10. ii	N 70 V	250–100	0610	—
	54° 08′ 45″ S, 33° 47′ 30″ W			500–250	—	0743
357	53° 07′ S, 34° 48′ W to	10. ii	N 70 V	100–50	1835	—
	53° 07′ 30″ S, 34° 45′ 30″ W			250–100	—	2217
358	53° 16′ 30″ S, 35° 02′ 30″ W to	11. ii	N 70 V	50–0	0113	—
	53° 17′ S, 34° 58′ W			100–50	—	0357
360	55° 53′ S, 32° 33′ W to	24–25. ii	N 70 V	50–0	2020	—
	55° 50′ S, 32° 26′ 30″ W			100–50	—	2330
361	55° 53′ 30″ S, 30° 46′ W to	25. ii	N 70 V	50–0	0909	—
	55° 52′ 30″ S, 30° 44′ W			100–50		
				250–100	—	1220
362	56° 04′ S, 29° 15′ W to	25. ii	N 70 V	50–0	1835	—
	56° 03′ 15″ S, 29° 20′ W			100–50		
				250–100	—	2146
365	56° 55′ S, 27° 02′ W to	2. iii	N 70 V	50–0	1305	—
	56° 53′ S, 26° 59′ W			100–50		
				250–100		
				500–250	—	1505

Table I (*cont.*)

Station	Position	Date	Net	Depth m.	Time	
					Shot	Hauled
		1930				
368	Douglas Strait, Southern Thule, S. Sandwich Is., one mile N. of Twitcher Rock	8. iii	N 70 V	50–0	1000	—
				100–50		
				250–100		
				500–250	—	1050
369	59° 17′ 15″ S, 26° 57′ W	9. iii	N 70 V	50–0	0855	—
				250–100	—	1053
372	57° 57′ S, 29° 53′ W	18–19. iii	N 70 V	50–0	2214	—
				100–50		
				250–100	—	0004
373	58° 00′ S, 33° 44′ W	19. iii	N 70 V	50–0	1959	2204
374	57° 55′ S, 37° 30′ W	20. iii	N 70 V	50–0	1847	—
				100–50	—	2135
375	57° 47′ S, 40° 49′ W	21. iii	N 70 V	50–0	1343	—
				500–250	—	1624
378	62° 21′ 30″ S, 60° 36′ W	13. iv	N 70 V	50–0	1142	—
				100–50	—	1210
383	60° 32′ S, 62° 42′ W	14. iv	N 70 V	100–50	0703	—
				250–100	—	1035
393 A	54° 17′ S, 35° 30′ W	7. v	N 70 V	150–75	1321	1420
393 D	54° 17′ S, 35° 30′ W	8. v	N 70 V	300–150	0255	0420
453	54° 05′ 30″ S, 3° 57′ 15″ E to 54° 07′ S, 4° 03′ E	16–17. x	N 70 V	50–0	2040	2341
			N 100 B	165–0	2353	0014
454	53° 42′ S, 4° 42′ E	17. x	N 100 B	192–0	2147	2203
455	53° 55′ 30″ S, 4° 47′ E	18. x	N 100 B	116–0	0327	0347
459	55° 09′ 15″ S, 2° 00′ E	19. x	N 100 B	183–0	2110	2130
460	56° 46′ S, 0° 41′ 45″ W	20–21. x	N 100 B	155–0	2049	2109
461 A	56° 44′ S, 2° 23′ 45″ W	21. x	N 100 B	80–0	1434	1454
				170–80	1434	1455
				270–170	1434	1455½
				385–270	1434	1456
				510–385	1434	1456½
				650–510	1434	1457
			N 70 V	50–0	1603	—
				750–500	—	1741
461 B	56° 44′ S, 2° 23′ W	21. x	N 100 B	75–0	1830	1848
				160–75	1830	1849
				255–160	1830	1849½
				345–255	1830	1850
				440–345	1830	1850½
				520–440	1830	1851
			N 70 V	50–0	1956	2127
461 C	56° 44′ S, 2° 22′ W	21–22. x	N 100 B	95–0	2236	2256
				200–95	2236	2257
				310–200	2236	2257½
				420–310	2236	2258
				535–420	2236	2258½
				660–535	2236	2259
			N 70 V	50–0	2344	—
				250–100	—	0130

Table I (*cont.*)

Station	Position	Date	Net	Depth m.	Time	
					Shot	Hauled
		1930				
461 D	56° 41′ S, 2° 24′ W	22. x	N 100 B	85–0	0237	0257
				180–85	0237	0258
				280–180	0237	0258½
				385–280	0237	0259
				490–385	0237	0259½
				600–490	0237	0300
			N 70 V	50–0	0355	—
				100–50	—	0516
461 E	56° 41′ S, 2° 24′ W	22. x	N 100 B	75–0	0629	0649
				245–160	0629	0650½
				330–245	0629	0651
				420–330	0629	0651½
				515–420	0629	0652
			N 70 V	50–0	0725	0842
461 F	56° 44′ S, 2° 22′ W	22. x	N 100 B	80–0	1025	1046
			N 70 V	50–0	1130	—
				100–50		
				250–100	—	1315
461 G	56° 44′ 45″ S, 2° 21′ 30″ W to	22. x	N 100 B	95–0	1429	1449
	56° 44′ 30″ S, 2° 21′ W			315–205 (–0)	1429	1456½
				700–560 (–315)	1429	1458
			N 70 V	50–0	1540	1736
462	56° 01′ S, 7° 28′ W	23. x	N 100 B	90–0	2159	2219
463	55° 42′ S, 10° 54′ W	24. x	N 100 B	132–0	2042	2102
464	56° 03′ S, 12° 18′ W	26. x	N 100 H	67(–0)	1028	1048
465	56° 49′ S, 14° 02′ 15″ W	26. x	N 100 B	113–0	2059	2117
466	55° 35′ S, 16° 31′ 30″ W	27. x	N 100 B	79–0	2053	2113
467	54° 39′ 30″ S, 19° 05′ 30″ W to	28–29. x	N 100 B	143–0	2039	2059
	54° 40′ 30″ S, 18° 58′ W					
469	54° 07′ 15″ S, 22° 01′ 45″ W	29. x	N 100 B	151–0	2141	2201
470	54° 42′ 30″ S, 26° 36′ 45″ W	30. x	N 100 B	91–0	2118	2138
471	54° 57′ S, 27° 59′ 30″ W	31. x–	N 70 V	50–0	1750	1937
		1. xi	N 100 B	168–0	2356	0016
472	53° 23′ S, 30° 29′ 30″ W	1. xi	N 100 B	111–0	2030	2050
475	53° 30′ 15″ S, 42° 44′ 30″ W	12. xi	N 100 B	165–0	1835	1855
477	53° 35′ 30″ S, 41° 25′ 45″ W	13. xi	N 70 V	50–0	0029	—
				100–50	—	0055
			N 100 B	132–0	0134	0153
480	53° 40′ 30″ S, 39° 54′ W	13. xi	N 100 B	161–0	1827	1849
481	53° 44′ 15″ S, 39° 29′ 30″ W	13–14. xi	N 100 B	139–0	0000	0020
				375–140	0000	0030
482	53° 46′ 45″ S, 39° 04′ 45″ W	14. xi	N 100 B	168–0	0519	0538
483	53° 54′ 15″ S, 38° 25′ 30″ W	14. xi	N 70 V	50–0	1315	—
				100–50	—	1350
			N 100 B	110–0	1418	1438
484	53° 52′ 15″ S, 37° 05′ 30″ W	16. xi	N 70 V	50–0	0738	—
				100–50		
				150–100	—	0814
			N 100 B	73–0	0825	0845

Table I (*cont.*)

Station	Position	Date	Net	Depth m.	Time	
					Shot	Hauled
		1930				
485	53° 37′ 15″ S, 37° 18′ W	16. xi	N 70 V	50–0	1021	—
				180–100	—	1055
			N 100 B	133–0	1124	1144
486	53° 24′ 15″ S, 37° 29′ 45″ W	16. xi	N 70 V	50–0	1326	1514
			N 100 B	124–0	1603	1623
				375–124	1603	1637
487	53° 11′ 30″ S, 37° 41′ 45″ W	16. xi	N 100 B	108–0	2210	2230
488	52° 59′ 45″ S, 37° 48′ W	17. xi	N 100 B	111–0	0052	0112
				370–111	0052	0120
			N 70 V	50–0	0138	0331
489	52° 48′ 15″ S, 38° 04′ W	17. xi	N 100 B	167–0	0950	1010
				400–167	0950	1020
490	52° 35′ S, 38° 13′ 30″ W	17. xi	N 100 B	140–0	1540	1601
491	52° 22′ S, 38° 22′ 45″ W	17. xi	N 70 V	250–100	1849	—
				500–250	—	2050
			N 100 B	164–0	2121	2141
492	53° 12′ 45″ S, 37° 04′ 15″ W	18. xi	N 100 B	148–0	1312	1335
493	52° 35′ 45″ S, 35° 26′ 15″ W	18–19. xi	N 100 B	155–0	0135	0155
				365–155	0135	0207
494	52° 50′ 30″ S, 35° 35′ 45″ W	19. xi	N 100 B	160–0	0826	0846
495	53° 04′ 45″ S, 35° 43′ 45″ W	19. xi	N 100 B	186–0	1413	1437
496	53° 17′ 45″ S, 35° 56′ W	19. xi	N 100 B	155–0	2019	2039
498	54° 00′ 30″ S, 36° 22′ W	21. xi	N 100 B	137–0	1450	1510
499	53° 44′ 30″ S, 36° 16′ W	21. xi	N 100 B	155–0	1804	1824
500	53° 30′ S, 36° 09′ 30″ W	21. xi	N 70 V	500–250	2004	2250
			N 100 B	142–0	2308	2328
502	53° 47′ S, 33° 51′ 45″ W	22. xi	N 100 B	132–0	2129	2149
503	53° 53′ 45″ S, 34° 12′ 45″ W	23. xi	N 70 V	50–0	0016	0212
			N 100 B	115–0	0316	0336
504	54° 00′ 45″ S, 34° 33′ 30″ W	23. xi	N 70 V	1000–750	0604	0740
506	54° 14′ S, 35° 15′ 30″ W	23. xi	N 100 B	161–0	1803	1823
507	54° 19′ 30″ S, 35° 33′ 30″ W	23. xi	N 100 B	75–0	2012	2032
508	55° 08′ S, 33° 35′ W	24. xi	N 100 B	181–0	1440	1500
509	55° 05′ 30″ S, 34° 01′ W	24. xi	N 100 B	112–0	2003	2023
510	4·8 miles N 70° E of Clerke Rocks, S. Georgia	25. xi	N 100 B	149–0	0817	0837
511	54° 58′ 15″ S, 34° 51′ 15″ W	25. xi	N 100 B	71–0	1115	1135
512	54° 56′ S, 35° 17′ W	25. xi	N 100 B	137–0	1410	1430
513	54° 53′ 45″ S, 35° 42′ 30″ W	25. xi	N 70 V	50–0	1606	1626
			N 100 B	71–0	1651	1711
514	55° 51′ S, 35° 32′ W	26. xi	N 100 B	155–0	0540	0600
			N 70 V	50–0	0625	—
				100–50	—	0755
516	55° 25′ 30″ S, 35° 52′ 45″ W	26. xi	N 100 B	123–0	1520	1540
517	54° 42′ 45″ S, 36° 36′ 45″ W	26. xi	N 70 V	50–0	2123	—
				100–50	—	2154
			N 100 B	102–0	2216	2236
518	54° 58′ S, 36° 23′ W	27. xi	N 100 B	90–0	0119	0139
519	55° 13′ S, 36° 09′ 30″ W	27. xi	N 100 B	137–0	0531	0551
520	55° 49′ S, 39° 07′ 15″ W	28. xi	N 100 B	155–0	0253	0318
			N 70 V	1000–750	0338	0504

Table I (*cont.*)

Station	Position	Date	Net	Depth m.	Time	
					Shot	Hauled
		1930				
521	55° 34′ 30″ S, 38° 43′ W	28. xi	N 100 B	164–0	1200	1220
522	55° 20′ 30″ S, 38° 19′ W	28. xi	N 100 B	95–0	1937	1957
523	55° 08′ 45″ S, 37° 59′ 45″ W	29. xi	N 100 B	157–0	0413	0433
525	54° 36′ 15″ S, 37° 23′ 30″ W	29. xi	N 100 B	110–0	1533	1553
528	55° 33′ S, 30° 15′ W	12. xii	N 100 B	173–0	2125	2145
537	61° 07′ 30″ S, 54° 26′ W	19. xii	N 70 V	250–100	0440	—
				500–250		
				750–500		
				1000–750	—	0634
			N 100 B	137–0	0645	0705
538	61° 29′ S, 54° 44′ 15″ W	19. xii	N 70 V	750–500	1003	—
				1000–750	—	1203
539	61° 48′ S, 54° 51′ 30″ W	19. xii	N 70 V	250–100	1445	—
				500–250		
				750–500		
				1000–750	—	1652
540	62° 06′ 15″ S, 55° 08′ 30″ W	19. xii	N 70 V	50–0	1926	—
				100–50		
				250–100		
				500–250	—	2010
541	62° 22′ S, 55° 23′ W	19–20. xii	N 70 V	50–0	2248	—
				100–50		
				250–100	—	2320
542	62° 08′ S, 57° 28′ 30″ W	20. xii	N 70 V	500–250	0700	0845
543	62° 16′ S, 57° 20′ W	20. xii	N 100 B	178–0	1205	1225
546	62° 46′ 15″ S, 57° 11′ 15″ W	20. xii	N 70 V	250–100	1919	—
				500–250	—	2000
547	62° 59′ 15″ S, 57° 03′ W	20. xii	N 100 B	37–0	2316	2336
558	65° 31′ S, 67° 07′ 45″ W	29. xii	N 70 V	100–50	2123	—
				200–100	—	2154
		1931				
585	67° 08′ 30″ S, 70° 15′ 30″ W	13. i	N 70 V	50–0	0346	0425
618	59° 42′ 45″ S, 43° 57′ 45″ W	18–19. ii	N 70 V	50–0	2235	—
				100–50		
				250–100		
				500–250		
				750–500	—	0110
620	59° 12′ S, 40° 23′ 30″ W	19–20. ii	N 70 V	50–0	2229	—
				100–50		
				250–100		
				750–500		
				1000–750	—	2359
622	59° 05′ 30″ S, 36° 25′ W	20–21. ii	N 70 V	50–0	2225	—
				100–50	—	2353
624	58° 34′ 45″ S, 31° 21′ 30″ W	21–22. ii	N 70 V	50–0	2235	0007
635	57° 42′ 45″ S, 50° 06′ 15″ W	7. iii	N 70 V	50–0	2017	—
				100–50		
				250–100	—	2250

Table I (*cont.*)

Station	Position	Date	Net	Depth m.	Time	
					Shot	Hauled
		1931				
636	59° 01′ 45″ S, 49° 18′ 30″ W	8. iii	N 70 V	250–100	0941	—
				500–250		
				750–500	—	1230
637	60° 00′ 15″ S, 49° 28′ 15″ W	8. iii	N 70 V	100–50	1907	—
				250–100		
				500–250		
				750–500		
				1000–750	—	2028
638	61° 00′ 30″ S, 49° 48′ 30″ W	9. iii	N 70 V	250–100	0537	—
				500–250		
				750–500		
				1000–750	—	0730
639	61° 57′ 45″ S, 51° 59′ W	9. iii	N 70 V	50–0	2107	—
				100–50		
				250–100		
				500–250		
				750–500	—	2240
644	61° 20′ 30″ S, 56° 40′ W	11. iii	N 70 V	100–50	0700	—
				250–100	—	0732
646	60° 22′ 30″ S, 57° 43′ W	11. iii	N 70 V	250–100	1537	—
				500–250	—	1770
647	59° 29′ 15″ S, 58° 39′ 45″ W	12. iii	N 70 V	50–0	0110	—
				100–50		
				250–100		
				500–250		
				750–500		
				1000–750	—	0328
648	58° 30′ 45″ S, 59° 41′ 15″ W	12. iii	N 70 V	50–0	1106	—
				100–50		
				250–100		
				500–250	—	1239
661	57° 36′ S, 29° 54′ 30″ W to 57° 36′ S, 29° 35′ W	2. iv	TYF B	360–0	0136	0226
		1932				
852	58° 39·5′ S, 40° 03·9′ E	18. iv	N 100 B	119–0	0429	0449
853	61° 00·2′ S, 43° 11·1′ E	19. iv	N 100 B	119–0	0435	0455
854	63° 30·2′ S, 46° 24·9′ E	20. iv	N 100 B	119–0	0342	0402
				248–94	0255	0330
855	65° 10·4′ S, 48° 43·7′ E	20. iv	N 100 B	125–0	2310	2330
				280–154	2310	2340
861	56° 28·9′ S, 79° 18·2′ E	28. iv	N 100 B	109–0	0019	0039
				254–110	0019	0049
862	55° 33·8′ S, 83° 00·4′ E	28. iv	N 100 B	102–0	2313	2333
				220–98	2313	2343
887	63° 41·4′ S, 130° 07′ E	27. v	N 100 B	86–0	2119	2139
				235–115	2119	2149
				120–0	2202	2222
			N 100 H	0–5	2213	2233

Table I (*cont.*)

Station	Position	Date	Net	Depth m.	Time	
					Shot	Hauled
		1932				
888	63° 23·2′ S, 130° 29·7′ E	28. v	N 100 B	98–0	0655	0715
				240–90	0655	0725
912	61° 02′ S, 158° 26′ E	24. vi	N 100 H	0–2	1240	1310
954	62° 18·2′ S, 128° 16·2′ W	9. ix	N 100 H	0–2	1115	1145
955	62° 17·2′ S, 158° 13·2′ W	9. ix	N 100 H	0–2	1210	1240
956	62° 12·8′ S, 158° 11′ W	9. ix	N 100 B	97–0	1351	1411
				280–100	1351	1421
957	61° 56·3′ S, 155° 49·6′ W	10. ix	N 100 H	0–2	1046	1116
959	61° 07′ S, 153° 57·2′ W	10–11. ix	N 100 H	0–5	2350	0012
			N 100 B	91–0	0012	0032
				240–110	0012	0042
994	66° 45·7′ S, 80° 19·8′ W	29. x	N 100 H	0–5	2155	2255
995	67° 06·2′ S, 79° 55·8′ W	30. x	N 70 B	320–120	0342	0412
996	66° 53·8′ S, 78° 52·6′ W	30. x	N 100 H	0–5	1735	1755
998	66° 40·7′ S, 75° 13·7′ W	31. x	N 100 H	3–4	1158	1230
999	66° 55·8′ S, 73° 51·5′ W	31. x	N 70 B	151–0	2207	2227
			N 100 H	0–5	2207	2237
1000	65° 06·6′ S, 71° 39·7′ W	1. xi	N 100 B	128–0	1108	1128
1001	64° 53·8′ S, 68° 43·9′ W	1. xi	N 100 B	95–0	2143	2203
				230–66	2143	2213
			N 100 H	0–5	2147	2207
1002	64° 23·4′ S, 65° 44·5′ W	2. xi	N 70 B	86–0	0952	1012
			N 100 B	86–0	0952	1012
			N 70 B	230–94	0952	1022
1003	63° 40·7′ S, 63° 07·7′ W	2. xi	N 70 B	115–0	2050	—
			N 100 B	115–0	—	2112
	R.R.S. ‘William Scoresby’	1928				
WS 139	53° 00′ S, 49° 50′ W	10. ii	N 70 V	500–250	1840	2240
WS 141	53° 32′ S, 44° 52′ W	13. ii	N 70 V	250–100	1250	—
				500–250	—	1543
WS 147	53° 50′ S, 35° 50′ W	21. ii	N 70 V	250–100	2120	2310
WS 182	55° 30′ S, 34° 50′ W	8. iii	N 70 V	250–100	0355	0715
WS 197	56° 00′ S, 40° 50′ W	17. iv	N 70 V	100–50	0530	—
				250–100		
				500–265		
				750–500		
				1000–800	—	0915
WS 198	57° 31′ S, 42° 52′ W	19. iv	N 70 V	250–100	1310	—
				500–250	—	1610
WS 199	58° 10′ S, 44° 10′ W	20. iv	N 70 V	500–250	1025	1255
WS 200	59° 05′ S, 46° 32′ W	21. iv	N 70 V	500–250	1220	—
				750–500	—	1420
WS 201	59° 57′ S, 50° 12′ W	22. iv	N 70 V	50–0	1847	—
				100–50		
				250–100		
				500–250	—	2255
WS 202	60° 23′ S, 52° 52′ W	23. iv	N 70 V	100–50	1845	—
				250–100		
				500–250	—	2115

Table I (*cont.*)

Station	Position	Date	Net	Depth m.	Time	
					Shot	Hauled
		1928				
WS 254	53° 03′ S, 46° 58′ W	22. viii	N 100 B	91–0	1339	1400
WS 255	53° 23′ S, 44° 10′ W	22–23. viii	N 70 V	50–0	2335	0310
			N 100 B	96–0	0329	0350
WS 256	53° 42′ S, 40° 33′ W	23–24. viii	N 100 B	100–0	0150	0211
WS 257	54° 04′ S, 36° 18′ W	27. viii	N 100 B	84–0	1728	1748
WS 258	53° 56′ S, 36° 06′ W	27. viii	N 100 B	91–0	2055	2118
WS 259	53° 49′ S, 35° 53′ 30″ W	27–28. viii	N 100 B	103–0	0332	0353
WS 260	53° 42′ S, 35° 41′ W	28. viii	N 100 B	86–0	0515	0535
WS 261	53° 34′ 30″ S, 35° 28′ 30″ W	28. viii	N 100 B	104–0	1031	1051
WS 262	53° 27′ S, 35° 17′ W	28. viii	N 100 B	85–0	1200	1223
WS 263	53° 20′ S, 35° 04′ W	28. viii	N 70 V	500–250	1320	1630
			N 100 B	87–0	1710	1730
WS 264	53° 13′ 30″ S, 34° 51′ W	28. viii	N 100 B	97–0	1848	1908
WS 265	52° 40′ S, 37° 05′ W	29. viii	N 100 B	130–0	1230	1250
WS 266	52° 50′ S, 35° 05′ W	29. viii	N 70 V	750–500	1420	—
				1000–760	—	1640
			N 100 B	89–0	1713	1733
WS 267	53° 01′ S, 37° 05′ W	29. viii	N 100 B	79–0	1845	1907
WS 268	53° 11′ S, 37° 05′ W	29. viii	N 70 V	250–100	2020	2300
			N 100 B	106–0	2321	2341
WS 269	53° 21′ S, 37° 05′ W	30. viii	N 100 B	100–0	0100	0120
WS 270	53° 31′ S, 37° 05′ W	30. viii	N 70 V	50–0	0240	0415
			N 100 B	116–0	0500	0520
WS 271	53° 42′ S, 37° 05′ W	30. viii	N 100 B	91–0	0721	0741
WS 272	53° 52′ S, 37° 05′ W	30. viii	N 100 B	87–0	0955	1015
WS 273	53° 24′ S, 39° 00′ W	4. ix	N 100 B	124–0	0635	0655
WS 274	53° 30′ S, 38° 47′ W	4. ix	N 70 V	250–100	0810	1035
			N 100 B	113–0	1132	1152
WS 275	53° 38′ S, 38° 34′ W	4. ix	N 70 V	100–0	1305	—
				750–500	—	1535
WS 276	53° 45′ S, 38° 22′ W	4. ix	N 100 B	104–0	2200	2220
WS 278	54° 23′ S, 35° 52′ W	12. ix	N 100 B	124–0	1938	1958
WS 279	54° 23′ S, 35° 35′ W	13. ix	N 100 B	114–0	1818	1838
WS 280	54° 23′ S, 35° 18′ W	17. ix	N 100 B	92–0	1506	1526
WS 281	54° 23′ S, 35° 00′ W	17. ix	N 100 B	102–0	1646	1706
WS 282	54° 22′ 30″ S, 34° 43′ W	17. ix	N 70 V	50–0	1820	1919
			N 100 B	137–0	2052	2112
WS 283	54° 22′ S, 34° 25′ W	17. ix	N 100 B	78–0	2320	2340
WS 284	54° 21′ 45″ S, 34° 08′ W	18. ix	N 70 V	50–0	0625	0732
			N 100 B	100–0	0848	0908
WS 285	54° 21′ 30″ S, 33° 53′ 30″ W	18. ix	N 100 B	89–0	1021	1041
WS 286	55° 00′ S, 32° 55′ W	18. ix	N 70 V	50–0	1835	2050
			N 100 B	100–0	2202	2222
WS 287	54° 54′ S, 32° 08′ W	19. ix	N 70 V	50–0	0815	1055
			N 100 B	164–0	1150	1220
WS 288	54° 52′ S, 32° 19′ W	19. ix	N 100 B	102–0	1429	1449
WS 291	54° 53′ S, 35° 31′ W	2. x	N 100 B	120–0	1227	1247
WS 292	55° 02′ S, 35° 16′ 40″ W	3. x	N 100 B	78–0	1604	1620
WS 293	55° 09′ S, 35° 05′ W	3. x	N 100 B	64–0	1806	1823
WS 294	55° 17′ S, 34° 53′ W	3. x	N 100 B	98–0	1951	2011

Table I (*cont.*)

Station	Position	Date	Net	Depth m.	Time	
					Shot	Hauled
		1928				
WS 295	55° 23′ 40″ S, 34° 41′ W	3–4. x	N 70 V	50–0	2132	0108
			N 100 B	97–0	0140	0200
WS 296	55° 31′ S, 34° 29′ W	4. x	N 100 B	110–0	0338	0359
WS 297	55° 34′ 05″ S, 33° 14′ W	4. x	N 70 V	50–0	1020	1245
			N 100 B	111–0	1330	1350
WS 298	55° 27′ 30″ S, 32° 21′ 40″ W	5. x	N 100 B	94–0	1008	1028
WS 299	55° 18′ 30″ S, 32° 05′ 20″ W	5. x	N 100 B	100–0	1205	1225
WS 300	55° 07′ 30″ S, 31° 56′ 55″ W	5. x	N 100 B	100–0	1736	1756
WS 301	55° 00′ 05″ S, 32° 08′ 25″ W	5. x	N 100 B	88–0	1913	1937
WS 302	54° 57′ 20″ S, 31° 49′ 35″ W	6. x	N 100 B	98–0	0522	0542
WS 303	54° 51′ 25″ S, 31° 20′ 10″ W	6. x	N 100 B	109–0	1312	1332
WS 304	54° 54′ 40″ S, 30° 21′ 20″ W	6. x	N 100 B	110–0	1843	1908
			N 70 V	50–0	1920	2205
WS 305	54° 44′ S, 29° 49′ W	7. x	N 100 B	100–0	0945	1005
WS 306	54° 41′ 50″ S, 30° 49′ 35″ W	7. x	N 100 B	105–0	1427	1447
WS 307	54° 19′ 30″ S, 30° 31′ 30″ W	7. x	N 100 B	120–0	1751	1811
			N 70 V	50–0	1840	2125
WS 308	54° 04′ 05″ S, 30° 18′ W	8. x	N 100 B	97–0	0830	0850
WS 309	53° 58′ 50″ S, 28° 50′ 10″ W	8. x	N 100 B	91–0	1610	1630
WS 310	54° 00′ S, 28° 38′ W	8. x	N 100 B	100–0	1800	1820
			N 70 V	50–0	1835	2055
WS 311	54° 45′ S, 35° 11′ W	10. x	N 100 B	116–0	1811	1839
WS 323	53° 38′ 30″ S, 38° 35′ 10″ W	20–21. xii	N 70 V	500–250	2205	0000
		1929				
WS 377	58° 34′ S, 44° 47′ W	9. ii	N 70 V	100–50	1445	1710
WS 380	60° 22′ S, 50° 33′ W	12–13. ii	N 70 V	250–100	2115	—
				500–250	—	0015
WS 382	62° 15′ 35″ S, 58° 18′ 30″ W	15. ii	N 70 V	400–250	1335	1423
WS 385	62° 32′ S, 57° 55′ W	16. ii	N 70 V	500–250	0005	0215
WS 394	62° 51′ S, 60° 40′ W	18. ii	N 70 V	200–100	0759	0830
WS 427	53° 34′ S, 40° 10′ W	28–29. iv	N 70 V	50–0	2155	—
				100–50	—	2248
WS 464	53° 40′ S, 37° 33′ W	31. x	N 100 B	135–0	2200	2220
WS 468	55° 52′ S, 56° 53′ W	9–10. xi	N 100 B	193–0	0055	0115
WS 474	61° 03′ S, 56° 42′ W	13. xi	N 100 B	100–0	2301	2321
WS 476	62° 16′ S, 58° 18′ W	14. xi	N 100 B	91–0	2054	2115
WS 477	62° 20′ 30″ S, 58° 14′ W	14–15. xi	N 70 V	1000–500	2150	0140
			N 100 B	140–0	0210	0230
WS 478	62° 24′ 30″ S, 58° 06′ 30″ W	15. xi	N 100 B	146–0	1535	1555
WS 480	62° 51′ 30″ S, 57° 47′ 30″ W	16. xi	N 70 V	200–100	0430	—
				500–200	—	0714
			N 100 B	100–0	0729	0749
WS 481	62° 59′ S, 57° 28′ W	16. xi	N 100 B	109–0	1046	1108
WS 482	63° 10′ S, 57° 16′ 30″ W	16. xi	N 100 B	54–0	1325	1336
WS 483	62° 46′ 45″ S, 59° 37′ 30″ W	21. xi	N 70 V	500–240	0705	0905
WS 484	62° 54′ S, 59° 28′ W	21. xi	N 70 V	750–500	1155	—
				950–740	—	1352

Table I (*cont.*)

Station	Position	Date	Net	Depth m.	Time	
					Shot	Hauled
		1929				
WS 485	63° 02′ 30″ S, 59° 17′ W	21. xi	N 70 V	500–250	1635	—
				750–500	—	1755
			N 100 B	164–0	1840	1900
WS 486	63° 11′ 30″ S, 59° 13′ W	21. xi	N 70 V	500–250	2020	—
				700–500	—	2135
			N 100 B	109–0	2215	2235
WS 487	63° 17′ S, 59° 20′ W	22. xi	N 70 V	500–250	0430	0545
			N 100 B	101–0	0618	0638
WS 488	63° 51′ 30″ S, 62° 30′ W	22. xi	N 100 B	107–0	1755	1815
WS 489	63° 38′ S, 62° 32′ W	22. xi	N 100 B	97–0	2125	2145
WS 490	63° 24′ 30″ S, 62° 35′ 30″ W	22–23. xi	N 100 B	98–0	0010	0030
WS 491	63° 12′ S, 62° 26′ W	23. xi	N 100 B	96–0	0334	0354
WS 496	67° 14′ S, 70° 12′ W	30. xii	N 70 V	50–0	0950	—
				100–50		
				600–250	—	1125
			N 100 B	106–0	1249	1309
		1930				
WS 497	67° 05′ S, 70° 40′ W	1. i	N 100 B	97–0	1344	1404
WS 498	66° 21′ S, 69° 01′ W	2–3. i	N 100 B	101–0	0132	0152
WS 499	65° 45′ S, 67° 18′ W	3. i	N 100 B	76–0	0903	0925
WS 501	64° 52′ S, 63° 58′ W	3. i	N 100 B	109–0	2248	2308
WS 505	70° 10′ 30″ S, 87° 46′ W	4. ii	N 70 V	100–50	1118	—
				250–100	—	1308
WS 508	69° 04′ S, 77° 40′ W	10. ii	N 100 B	91–0	0204	0224
WS 524	53° 36′ S, 43° 00′ W	2. iii	N 70 V	500–250	0750	0932
WS 527	57° 30′ S, 45° 35′ W	30. iii	N 70 V	50–0	0812	—
				100–50		
				250–100	—	1020
WS 529	56° 05′ S, 53° 45′ W	2. iv	N 70 V	500–250	0930	—
				750–500	—	1200
		1931				
WS 534	54° 17′ 30″ S, 35° 39′ W	22–23. i	N 70 V	50–0	2315	—
				100–50	—	0000
WS 538	57° 03′ 30″ S, 24° 32′ W	26. i	N 100 B	97–0	1335	1355
WS 540	57° 55′ S, 21° 21′ W	27–28. i	N 70 V	50–0	2245	—
				500–250		
				750–500	—	0230
WS 542	58° 39′ S, 18° 13′ W	28. i	N 100 B	77–0	2235	2255
WS 560	56° 27′ S, 28° 59′ W	9. ii	N 100 B	130–0	2140	2200
WS 570	52° 22′ S, 38° 23′ W	8. iii	N 70 V	250–0	1700	—
				750–0	—	2015
WS 572	53° 11′ 30″ S, 37° 41′ W	24. iii	N 70 V	250–100	1600	1855
WS 573	52° 59′ 45″ S, 37° 48′ W	25. iii	N 70 V	50–0	0127	0350

micro slide. Each larva was placed on the slide with the tail projecting into the angle, and was held up by the sides of the trough so that the total length from tip of rostrum to end of telson could be read quickly. The measurement of adolescents was done directly on a scale marked off in 0·5 mm. divisions.

A difficulty was encountered as a result of the preservation of the specimens. The greater mass of the material was preserved in formalin, but nearly all the samples taken by the 'William Scoresby' were in 70 per cent alcohol. A comparison of specimens preserved in alcohol with others from the same stations preserved in formalin showed that a considerable shrinkage had taken place in the specimens kept in the former fluid.

Table II

Station	Numbers averaged	Average length, mm.		*A* as percentage of *B*	Factor for expression of *A* as *B*
		(*A*) Preserved in spirit	(*B*) Preserved in formalin		
WS 263	94	9·99	10·94	91·4	1·096
WS 282	100	13·23	14·47	91·4	1·094
WS 286	100	11·20	12·47	89·8	1·113
WS 288	100	12·04	12·99	92·7	1·079
WS 296	50	14·75	15·79	93·4	1·070
WS 487	100	15·98	17·28	92·4	1·085

The actual figures are expressed in Table II. In order to make the specimens more nearly comparable as regards length the factor 1·09 was employed and records of length of spirit-preserved larvae were multiplied by it to bring them into line with the rest of the measurements.

ACKNOWLEDGMENTS

Whilst the work on this paper was in progress Dr Rustad published a paper on "Euphausiacea, with notes on their biogeography and development" (1930), and another "On the Antarctic euphausiids from the Norvegia Expeditions, 1929–30 and 1930–31" (Rustad, 1934). Dr Johan T. Ruud (1932) also published his paper "On the biology of southern Euphausiidae". I wish to make full acknowledgment to both of these authors for the use I have made of their publications, which are constantly referred to here.

Acknowledgments are due to Dr S. W. Kemp, F.R.S., for much helpful criticism and advice, to Dr W. T. Calman, C.B., F.R.S., to my colleague Mr D. Dilwyn John and former colleagues Dr N. A. Mackintosh and Dr H. E. Bargmann for the assistance they have given me. I am also greatly indebted to Mr G. E. R. Deacon for his valuable help where hydrographical problems were involved.

DEVELOPMENT

THE EGG

The eggs found in the plankton were identified as those of *E. superba* by comparison with others shed by gravid females, which from time to time were kept in tanks on board the R.R.S. 'Discovery II'. The appearance of the eggs is sufficiently distinct to enable them to be picked out with comparative ease from the plankton samples. They measure 0·6 mm. in diameter when unpreserved, but after formalin has been used there is a decrease in size; for example the average diameters of two batches of a hundred each from two different catches at St. 540 were respectively 0·56 and 0·59 mm. The average sizes obtained from smaller numbers agree closely with these figures. The eggs are opaque and rather densely granular; in reflected light their milky white appearance helps greatly to distinguish them. There is a thin, transparent, unsculptured membrane investing the contents of the egg, the latter completely filling the egg-shell. The average size of the eggs and the depths at which they are found do not seem to be correlated.

At St. 356, 10. ii. 30, 250–100 m., ninety-five adult *E. superba* were obtained in the 70-cm. net, although none were caught in other nets either vertical or oblique. Most of the females were gravid, with spermatophores inserted in the thelycum. Four gravid females were placed in an aquarium, and on the following day the distension of the cephalothorax had subsided and a number of eggs were found in the water. On dissecting a female many eggs were found floating in a milky fluid which appeared to consist of an emulsion of tiny oil globules. The eggs were of the same size as those in the aquarium, namely 0·6 mm. diameter.

At St. 548, 21. xii. 30, 102–0 m., eighty *E. superba* were taken, among them several gravid females. Two of these females were placed in a vessel containing sea water on the upper bridge of the ship, and on December 23, between 2 and 4 a.m., both shed their eggs. The females did not cast their skins beforehand and one still had the spermatophores *in situ*. On December 29 the female without spermatophores died and the other died on the following day; neither had moulted.

Six gravid females were kept alive from St. 602, 19. i. 31, 110–0 m., and in due course eggs were deposited, but attempts to induce segmentation were unsuccessful. The eggs were divided into batches and subjected to varying degrees of temperature. Some were kept in an aquarium at laboratory temperatures, some in a plunger jar on deck at air temperature, and others in a vessel surrounded by lumps of ice. In all the experiments the water was filtered before the gravid females were placed in it.

Eggs occurred in the plankton showing all stages of development, culminating in the clearly distinguishable form of the 1st Nauplius, this latter completely filling the interior of the egg capsule.

Table III. *Occurrence of eggs*

Station	Date	Depth m.	Number	Average diameter* mm.	Remarks
356	10. ii. 30	250–100	—	—	Eggs from gravid female
537	19. xii. 30	250–100	2	0·55 (2)	
		500–250	8	0·57 (8)	1 adult in sample
		750–500	27	0·58 (27)	1 adult in sample
		1000–750	11	0·57 (10)	
538	19. xii. 30	750–500	2	0·55 (2)	4 adults in sample and cast skin of adult
		1000–750	8	0·58 (8)	
539	19. xii. 30	250–100	3	0·57 (3)	
		500–250	7	0·59 (7)	
		750–500	6	0·57 (6)	
		1000–750	9	0·58 (9)	
540	19. xii. 30	50–0	4	0·57 (4)	
		100–50	52	0·58 (51)	
		250–100	478	0·56 (100)	
		500–250	2496	0·59 (100)	5 adults in sample
541	19. xii. 30	50–0	1	0·56 (1)	
		100–50	5	0·55 (5)	
		250–100	1	0·56 (1)	
542	20. xii. 30	500–250	1	0·56 (1)	
546	20. xii. 30	500–250	4	0·58 (4)	1 adult picked out
558	29. xii. 30	100–50	1	0·58 (1)	3 other eggs not *E. superba*
585	13. i. 31	50–0	1	0·60 (1)	
618	18/19. ii. 31	250–100	1	0·58 (1)	
637	8. iii. 31	250–100	1	0·55 (1)	
644	11. iii. 31	100–50	4	0·59 (4)	
		250–100	6	0·59 (6)	
WS 147	21. ii. 28	250–100	1	0·60 (1)	
WS 323	20. xii. 28	500–250	1	0·58 (1)	
WS 377	9. ii. 29	100–50	1	0·56 (1)	At St. WS 376, 750–500 m., 4 adult males, 2 adult and gravid females with spermatophores attached
WS 380	12. ii. 29	250–100	2	0·56 (2)	
		500–250	2	0·61 (2)	
WS 382	15. ii. 29	400–250	2	0·55 (2)	
WS 385	16. ii. 29	500–250	1	0·60 (1)	
WS 394	18. ii. 29	200–100	1	0·60 (1)	
WS 477	14. xi. 29	1000–500	1	0·58 (1)	
WS 480	16. xi. 29	200–100	13	0·57 (12)	
		500–200	70	0·60 (10)	2 females with enlarged ovaries in this sample
WS 483	21. xi. 29	500–250	1	0·56 (1)	
WS 484	21. xi. 29	750–500	1	0·56 (1)	
		950–750	1	0·55 (1)	
WS 485	21. xi. 29	500–250	3	0·54 (3)	
		750–500	2	0·58 (2)	
WS 486	21. xi. 29	500–250	1	0·56 (1)	
		750–500	1	0·52 (1)	
WS 487	22. xi. 29	500–250	1	0·56 (1)	
WS 496	30. xii. 29	100–50	1	0·58 (1)	
		600–250	1	0·61 (1)	Shell broken
WS 505	4. ii. 30	250–100	2	0·56 (2)	

* Number from which the average was taken is shown in brackets.

FIRST NAUPLIUS

As shown in Table IV there are only two records of free-swimming 1st Nauplii in the material examined, but at some of the stations where eggs were found, notably at St. 537, many of the eggs contained well-developed naupliar forms. A Nauplius measuring 0·62 mm. in length (Fig. 1 *a*) was dissected from an egg, the interior of which it completely occupied. This differs somewhat from Ruud's description (1932, pp. 47, 49, fig. 11), in which the Nauplius in the egg is stated to be 0·51 mm. long and does not completely occupy the space within the egg-shell.

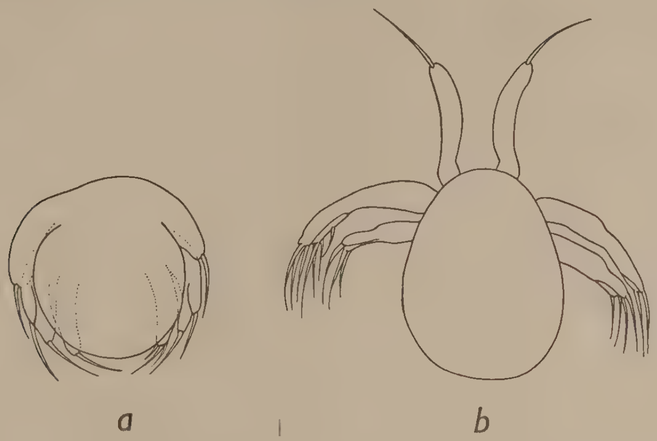

Fig. 1. First Nauplius (× 46). *a*, specimen dissected from egg; *b*, free-swimming specimen.

Table IV. *Occurrence of First Nauplius*

Station	Date	Depth m.	Number	Length mm.
537	19. xii. 30	750–500	1	0·63
539	19. xii. 30	250–100	1	0·66

Of the two free-swimming larvae one measured 0·63 and the other 0·66 mm. They were presumed to be *E. superba* from their relatively large size compared with other Nauplii in the plankton, from their similarity to nearly hatched Nauplii dissected from eggs of *E. superba*, and from their occurrence at stations containing recognizable eggs of this species.

The body of the Nauplius is in dorsal aspect oval in shape, broader posteriorly than anteriorly (Fig. 1 *b*). It is in form a normal 1st Nauplius with three pairs of swimming appendages. The first pair of limbs is uniramous with the two succeeding pairs biramous.

SECOND NAUPLIUS

All the 2nd Nauplii occurred at stations where eggs were present; because of this, but particularly on account of their large size, they were assumed to be *E. superba*. The average length of the 2nd Nauplius is 0·67 mm. with a range of from 0·63 to 0·70 mm.

Table V. *Occurrence of Second Nauplius*

Station	Date	Depth m.	Number	Length mm.	Remarks
540	19. xii. 30	250–100	1	0·70	
546	20. xii. 30	250–100	1	0·68	
558	29. xii. 30	200–100	1	0·65	
WS 480	16. xi. 29	500–200	1	0·65	Female with enlarged ovaries in net
WS 483	21. xi. 29	500–250	1	0·63	A damaged specimen
WS 484	21. xi. 29	750–500	1	0·66	
WS 486	21. xi. 29	500–250	1	0·69	

The outline of the body in dorsal aspect is roughly oval (Fig. 2*b*), truncated at the posterior end and tending to be pointed, rather than rounded, at the anterior end. At each postero-lateral corner of the body there are two spines, a longer inner one about one-quarter to one-third of the length of the body, and a shorter outer one about one-tenth of the length of the first-mentioned spine. Three pairs of appendages are developed (Fig. 2*a*). The antennules are uniramous with two terminal setae; the antennae are biramous, having six terminal setae on the inner ramus and three terminal and one lateral on the outer. Posterior to the antennae are the biramous mandibles, each ramus having three setae distally.

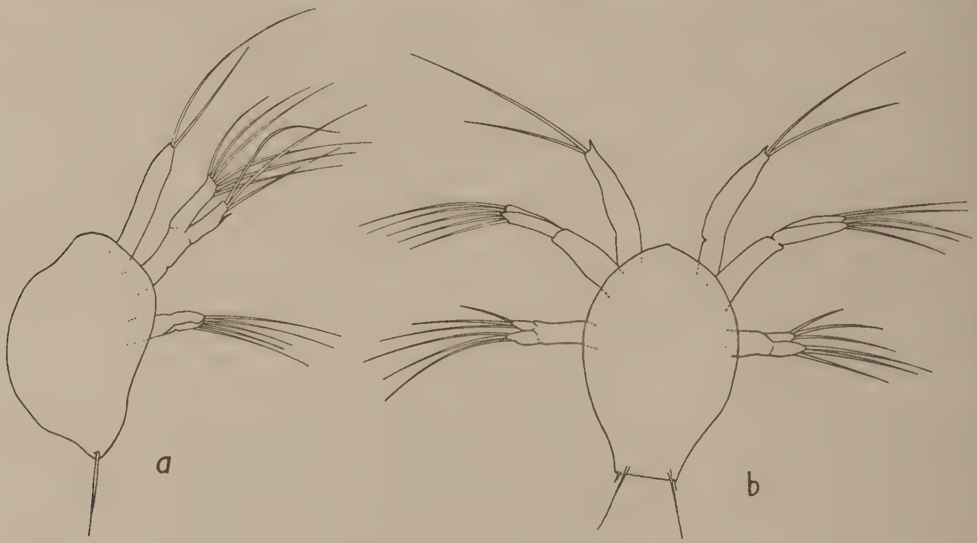

Fig. 2. Second Nauplius (× 46). *a*, lateral aspect; *b*, dorsal aspect.

METANAUPLIUS

In appearance the Metanauplius is very robust and of great size in comparison with other euphausian Metanauplii found in the same region. The average lengths of the larvae from different stations are given in Table VI. A hundred Metanauplii from St. 647, 750–500 and 1000–750 m. respectively, were measured and give normal length frequency curves (Table VII), with the two averages closely similar to one another, namely 0·97 and 0·92 mm. The length ranges between 0·90 and 1·05 mm. in the first group and between 0·84 and 0·98 mm. in the second. The extreme range of size is between 0·84 and 1·08 mm. Ruud (1932, p. 47) states that the length of the body in the Metanauplii of *E. superba* examined by him is from 0·72 to 0·82 mm. He also states that the carapace of all the specimens was rather swollen, so that his larvae must have been considerably smaller than any found in the present material.

Table VI. *Occurrence of Metanauplius*

Station	Date	Temperature range ° C.	Depth m.	Number	Average length mm.
193	28. iii. 27	−0·26 to −0·66	500–250	1	1·08
618	18/19. ii. 31	0·79 to 0·89	750–500	20	0·92
620	19/20. ii. 31	0·43 to 1·01	750–500	2	0·98
			1000–750	4	0·90
636	8. iii. 31	0·70 to 1·46	750–500	17	0·91 (13)*
637	8. iii. 31	0·03 to −0·22	750–500	24	0·94
			1000–750	10	0·93
638	9. iii. 31	−0·19 to −0·85	250–100	1†	—
			750–500	3	0·93
			1000–750	4	0·91
639	9. iii. 31	−0·76 to −0·99	50–0	2	0·95
647	12. iii. 31	1·34 to 2·01	750–500	3702	0·97 (100)*
			1000–750	577	0·92 (100)*
648	12. iii. 31	1·11 to 3·76	50–0	7	0·85
			100–50	49	0·93 (47)*
			250–100	4	0·93
			500–250	9	0·94 (3)*
WS 197	17. iv. 28	1·33 to 1·27	1000–750	115	0·96 (88)*

* The figure in brackets is the number from which the average length was calculated when all specimens were not measured.

† Larva damaged.

Table VII. *Length frequencies of Metanauplius from St.* 647

750–500 m.			1000–750 m.		
Micro-divisions	Length mm.	Frequency	Micro-divisions	Length mm.	Frequency
56	0·90	4	52	0·84	2
57	0·92	2	53	—	—
58	0·94	10	54	0·87	5
59	0·95	22	55	0·89	16
60	0·97	41	56	0·90	21
61	0·98	5	57	0·92	25
62	1·00	7	58	0·94	17
63	1·02	3	59	0·95	7
64	1·03	4	60	0·97	5
65	1·05	2	61	0·98	2
Av. length 0·97 mm.			Av. length 0·92 mm.		

The carapace (Figs. 3 *a*, *b*) which envelops the anterior portion of the body and part of the abdomen is without marginal spines or processes. It is tucked in under the body posterolaterally, so that when it is dissected and flattened out (Fig. 3 *d*) the posterior portion is wider than the anterior. At the anterior margin of the body underneath the carapace a small pair of frontal sense organs can be distinguished. There are traces of the paired eyes of the adult and of the median eye, although the latter is not easily seen. The compound eyes are in the form of two roughly spherical masses, and each contains a bunch of fibres within its tissues which is the developing luminous organ of the ocular peduncle (cf. Metschnikoff, 1869, pp. 479, 481, fig. xxxvi). The abdomen is

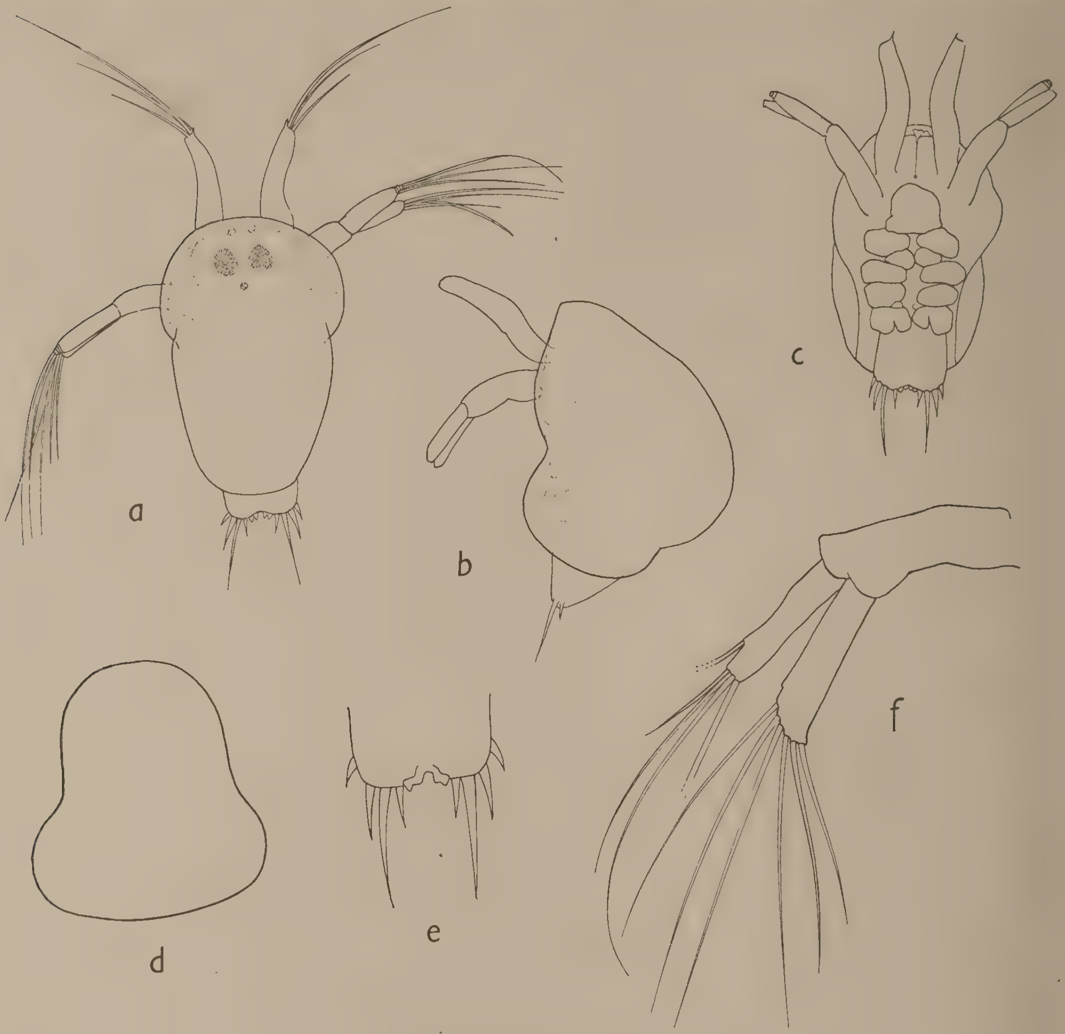

Fig. 3. Metanauplius.

a, dorsal aspect (× 46);
b, lateral aspect (× 46);
c, ventral aspect (× 46);
d, extended carapace (× 46);
e, telson (× 100);
f, antenna (× 100).

In Figs. 3 *b* and *c* the bristles on the appendages have been omitted.

short, tapering in lateral view and slightly bilobed in dorsoventral aspect. The posterior margin (Fig. 3 *e*) is armed with twelve spines, of which the pair on either side of the emargination are very short and incompletely separated from one another.

The antennules are unsegmented and uniramous, bearing three long bristles at their tips. The antennae (Fig. 3 *f*) are biramous and also furnished with long bristles. The mandibles are in this stage reduced and bud-like in appearance. Maxillae I and II are rudimentary single-lobed buds, and the first thoracic legs are small bilobed processes without setae. Anterior to the mandibles lies the labrum and posteriorly between the mandibles and the 1st maxillae the bilobed labium (Fig. 3 *c*).

FIRST CALYPTOPIS

The average lengths and the ranges of length for varying numbers of 1st Calyptopis are stated in Table VIII. The extreme range for 500 individuals from an oblique net fished at St. 647 is between 1·33 and 1·92 mm. The frequency distribution of these larvae is as follows:

Length, mm.	1·33	1·38	1·41	1·46	1·50	1·54	1·58	1·63	1·67	1·71	1·75	1·79	1·83	1·88	1·92
Frequency	3	1	1	3	7	19	41	51	78	62	78	73	67	15	1

Their average length is 1·71 mm. The lengths of all the other larvae fall within the limits of the stated range, as do the lengths of those examined by Ruud (1932, p. 47).

The carapace is without teeth or projections (Figs. 4 *a*, *b*). The median eye is present, and anterior to it are indications of the compound eyes. The rudiment of the ocular luminous organ can clearly be distinguished as a dark mass of fibres within the developing compound eye. There is also a pair of frontal sensory organs anteriorly.

The appendages, with one or two small differences in detail, are as described by Sars (1885) in *Nyctiphanes australis*. The two sensory appendages on the antennules are difficult to see in unstained specimens. The antenna (Fig. 4 *c*) is composed of a two-segmented peduncle and, distally, an inner and outer ramus as in the Metanauplius. In the mandible (Fig. 4 *d*) the dentiform projection between the dentate part and the molar protuberance is present; also, as in *N. australis*, the denticulated plate—the lacinia mobilis. At the base of the projection, where the plate is inserted, there is a bunch of setae surrounding it. The palp of the 1st maxilla consists of two segments as mentioned by Ruud (1932); it bears five spines as opposed to six in *N. australis*, three being at the tip of the distal segment and two on the inner margin of the proximal segment. The inner masticatory lobe is furnished with seven spines of varying structure and the outer lobe with three (Fig. 4 *e*). The larval exopod is as in Sars' description. The 2nd maxilla (Fig. 4 *f*) differs only from Sars' description in having three instead of four bristles on the terminal segment. The 1st thoracic limb (Fig. 4 *g*) differs from that figured by Sars for *N. australis* in having a short bristle at the articulation of the exopodite and the basipodite on the external margin.

The posterior portion of the body, behind the wrinkling of the integument which foreshadows the segmentation of later stages, is shorter than the anterior part. The abdomen is furnished with a pair of spines situated marginally but rather ventrally about one-third of the abdominal length from the distal end (Fig. 4 *h*). At the posterior end of the abdomen there are three pairs of postero-lateral spines increasing in length from the outer to the inner, and six terminal spines which increase in length from the innermost pair outwards. The longest terminal spine is about half the length of the longest postero-lateral.

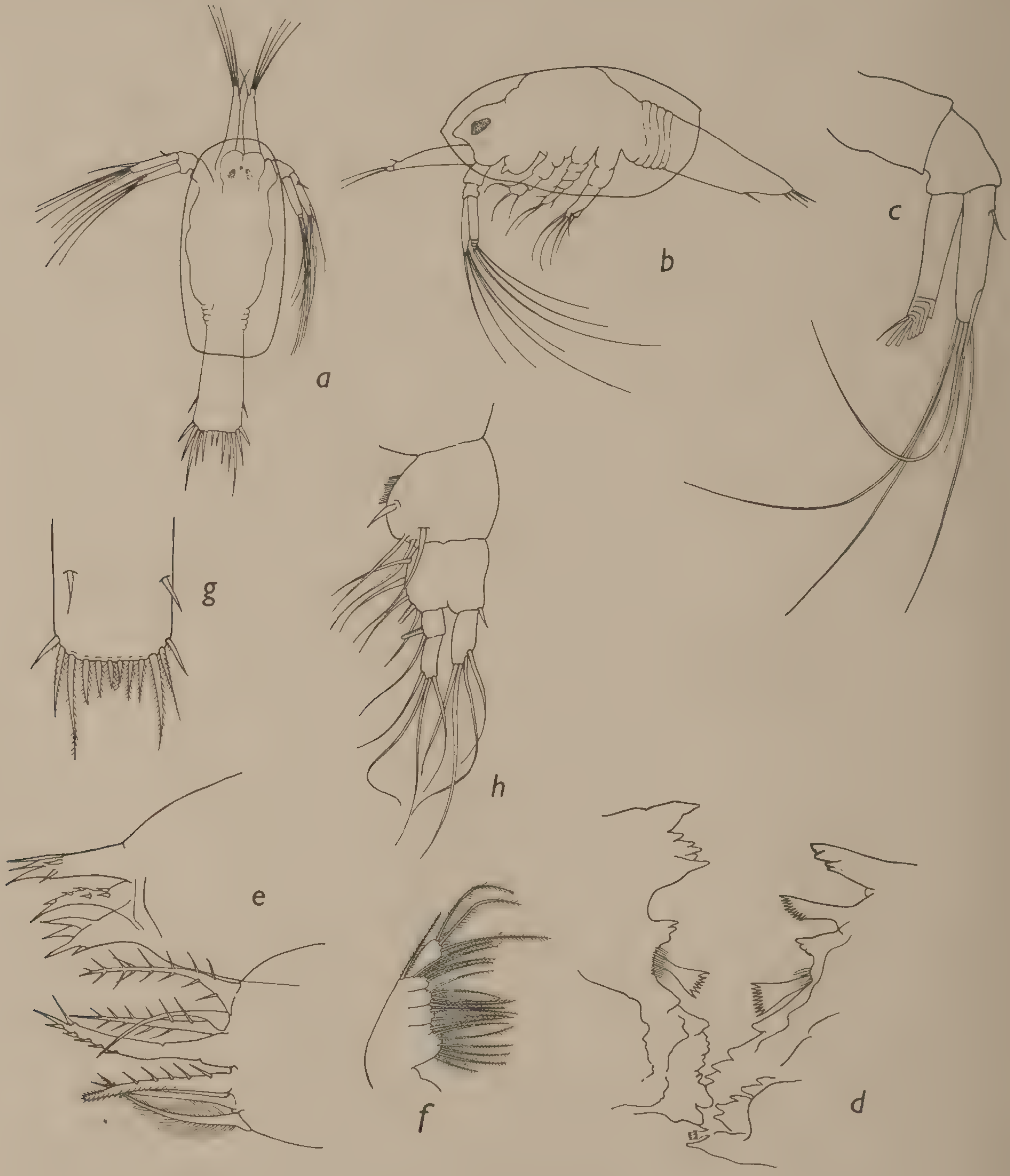

Fig. 4. First Calyptopis.

a, dorsal aspect (×20); *d*, mandibles (× 335); *g*, telson (×70);
b, lateral aspect (×25); *e*, masticatory lobes of the first maxilla (×315);
c, antenna (×65); *f*, second maxilla (× 70); *h*, first thoracic (limb) × 70.

Table VIII. *Occurrence of First Calyptopis*

Station	Date	Depth m.	No. of larvae	No. measured	Length range mm.	Average length mm.
161	14. ii. 27	100–50	1	1	1·71	1·71
169	22. ii. 27	500–250	3	3	1·54–1·79	1·65
194	28. iii. 27	100–50	3	3	1·79–1·88	1·85
		250–100	3	3	1·75–1·88	1·79
198	3. iv. 27	50–0	1	1	1·92	1·92
202	5. iv. 27	50–0	1	1	1·88	1·88
302	21. i. 30	500–250	1	1	1·75	1·75
305	21. i. 30	100–50	2	2	1·63–1·67	1·65
313	25. i. 30	750–500	1	1	1·71	1·71
319	29–30. i. 30	100–50	1	1	1·54	1·54
320	30. i. 30	500–250	1	1	1·63	1·63
332	31. i. 30	250–100	5	5	1·50–1·63	1·54
356	10. ii. 30	250–100	1	1	1·58	1·58
357	10. ii. 30	100–50	3	3	1·67–1·71	1·70
		250–100	2	2	1·75–1·88	1·82
365	2. iii. 30	250–100	1	1	1·75	1·75
378	13. iv. 30	50–0	1	1	1·79	1·79
		100–50	1	1	1·75	1·75
383	14. iv. 30	100–50	122	50	1·63–1·79	1·69
		250–100	24	6	1·63–1·88	1·72
618	18–19. ii. 31	50–0	142	99	1·58–1·88	1·75
		100–50	196	90	1·46–1·88	1·70
		250–100	5	5	1·67–1·79	1·74
		750–500	4	4	1·58–1·67	1·63
620	19–20. ii. 31	50–0	59	59	1·46–1·79	1·66
		100–50	148	100	1·50–1·83	1·70
		250–100	11	11	1·46–1·88	1·64
		750–500	10	10	1·42–1·75	1·58
		1000–750	6	6	1·50–1·67	1·58
622	20–21. ii. 31	50–0	30	5	1·67–1·75	1·70
		100–50	11	11	1·58–1·79	1·68
636	8. iii. 31	250–100	5	5	1·58–1·75	1·69
		500–250	31	28	1·46–1·88	1·64
		750–500	1	1	1·58	1·58
637	8. iii. 31	100–50	2	1	1·54	1·54
		250–100	21	21	1·42–1·75	1·59
		500–250	66	63	1·46–1·83	1·68
		750–500	2	—	—	—
		1000–750	4	4	1·58–1·71	1·67
638	9. iii. 31	500–250	4	4	1·58–1·75	1·67
		750–500	2	2	1·54	1·54
639	9. iii. 31	50–0	2	2	1·75–1·79	1·77
		100–50	117	100	1·42–1·88	1·63
		250–100	91	86	1·46–1·88	1·68
		500–250	3	3	1·58–1·75	1·65
		750–500	5	5	1·67–1·83	1·74
646	11. iii. 31	250–100	1	1	1·79	1·79
		500–250	2	2	1·71–1·75	1·73
647	12. iii. 31	50–0	361	100	1·46–1·83	1·63
		100–50	20	20	1·46–1·75	1·62
		250–100	94	87	1·46–1·88	1·69
		500–250	150	100	1·42–1·79	1·60
		750–500	282	50	1·42–1·88	1·68
		1000–750	7	7	1·50–1·79	1·67
648	12. iii. 31	100–50	7	7	1·58–1·71	1·64
		500–250	3	3	1·63–1·67	1·66
WS 139	10. ii. 28	500–250	2	2	1·54–1·75	1·65
WS 141	13. ii. 28	250–100	1	1	1·75	1·75
WS 182	8. iii. 28	250–100	2	2	1·58–1·67	1·63
WS 197	17. iv. 28	250–100	36	36	1·50–1·88	1·70
		500–250	28	28	1·50–1·88	1·71
		750–500	2	2	1·58–1·88	1·73
WS 198	19. iv. 28	250–100	1	1	1·75	1·75
WS 572	8. iii. 31	250–100	1	1	1·75	1·75

SECOND CALYPTOPIS

The average lengths and ranges of length for varying numbers of 2nd Calyptopis are stated in Table IX. The range of forty-eight larvae, the largest number measured in one sample, is between 2·38 and 2·96 mm. and the average is 2·71 mm. The smallest larva measured was 2·13 mm. and the largest 3·33 mm.

The carapace is evenly rounded and there are no lateral denticles (Figs. 5 *a*, *b*). The abdomen is segmented, and in lateral view the developing uropods can be seen within the integument. The telson (Fig. 5 *c*) is furnished with three postero-lateral spines on each side of the seven terminal spines. A spine is situated laterally on each side of the telson, as in the 1st Calyptopis. Both lateral and postero-lateral spines carry a diminutive dorsal spinule just beyond the middle of their length, as described by Rustad in *Euphausia frigida*. Posterior to the 1st pair of thoracic appendages are situated ventrally and side by side two roughly hemispherical lobes enclosed by the integument containing the buds of the following five pairs of thoracic legs. These lobes are a distinguishing feature of the 2nd Calyptopis of *E. superba*, and their presence is, of course, associated with the exceptionally early development of the thoracic appendages II–VI in this

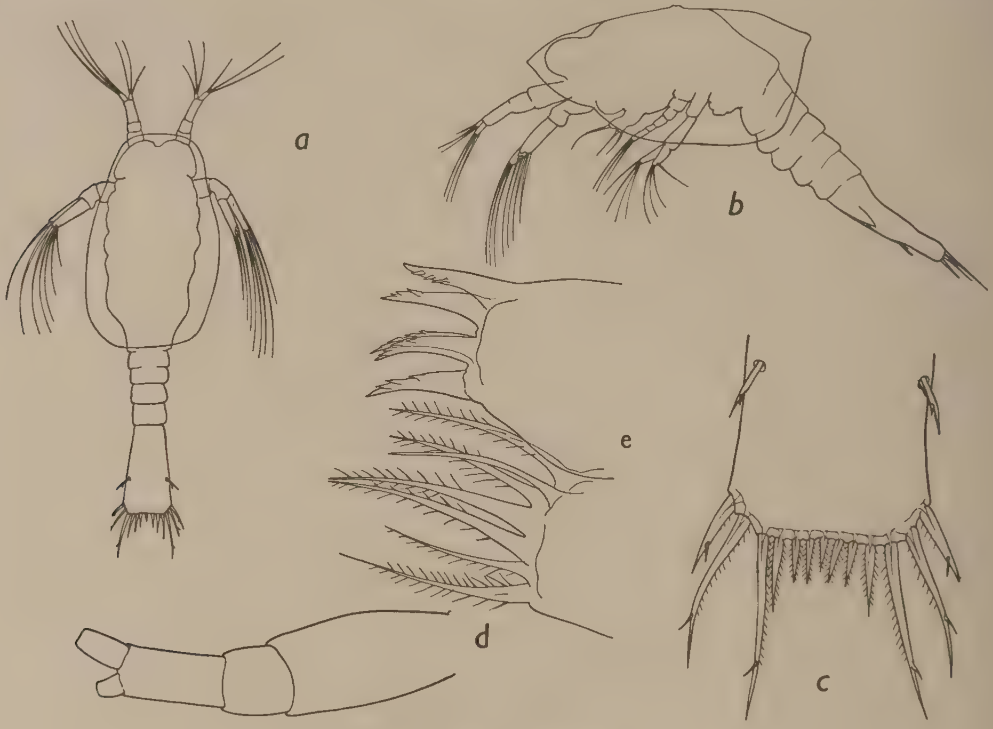

Fig. 5. Second Calyptopis.

a, dorsal aspect (× 19);
b, lateral aspect (× 25);
c, telson (× 80);
d, antennule (× 80);
e, masticatory lobes of the first maxilla (× 287).

Table IX. *Occurrence of Second Calyptopis*

Station	Date	Depth m.	No. of larvae	Number measured	Length range mm.	Average length mm.
161	14. ii. 27	100–50	6	6	2·92–3·21	2·98
167	20. ii. 27	250–100	1	1	2·71	2·71
169	22. ii. 27	500–250	3	3	2·50–2·75	2·61
187	18. iii. 27	100–50	1	1	2·92	2·92
193	28. iii. 27	500–250	11	7	2·92–3·17	3·07
		750–500	1	1	3·00	3·00
194	28. iii. 27	100–50	29	26	2·42–3·13	2·80
		250–100	17	17	2·42–3·00	2·72
197	3. iv. 27	100–50	1	1	2·92	2·92
		750–500	1	1	2·92	2·92
		1000–750	2	2	2·92–2·96	2·94
198	3. iv. 27	50–0	22	21	2·63–3·13	2·94
		100–50	5	5	2·71–3·08	2·92
		1000–750	1	1	2·92	2·92
199	3. iv. 27	500–250	2	2	3·00–3·08	3·04
202	5. iv. 27	50–0	3	3	2·54–2·79	2·68
204	6. iv. 27	500–250	3	3	3·00–3·13	3·07
205	6. iv. 27	215–100	2	2	2·92	2·92
206	6. iv. 27	250–100	2	2	3·00–3·13	3·07
209	14. iv. 27	150–100	1	1	2·75	2·75
302	21. i. 30	250–100	2	2	2·50–2·58	2·54
		500–250	6	6	2·71–2·92	2·79
303	21. i. 30	500–250	33	25	2·50–2·96	2·69
		750–500	1	1	2·71	2·71
304	21. i. 30	500–250	2	2	2·63	2·63
305	21–22. i. 30	100–50	5	5	2·46–2·63	2·54
		250–100	4	4	2·58–2·71	2·61
		500–250	2	2	2·63–2·83	2·73
313	25. i. 30	250–100	1	1	2·63	2·63
319	29–30. i. 30	50–0	5	1	2·58	2·58
320	30. i. 30	250–100	1	1	2·42	2·42
		500–250	28	17	2·42–2·67	2·54
321	30–31. i. 30	100–50	3	3	2·46–2·50	2·49
323	31. i. 30	500–250	5	5	2·50–2·67	2·59
		1000–750	1	1	2·67	2·67
332	2–3. ii. 30	250–100	2	2	2·42–2·50	2·46
344	7–8. ii. 30	100–50	2	2	2·42–2·71	2·52
345	8. ii. 30	180–100	1	1	2·58	2·58
356	10. ii. 30	250–100	8	8	2·58–2·96	2·74
		500–250	1	1	2·63	2·63
357	10. ii. 30	100–50	1	1	2·29	2·29
		250–100	2	2	2·42–2·58	2·50
358	11. ii. 30	50–0	11	11	2·58–2·75	2·67
		100–50	3	3	2·50–2·71	2·61
361	25. ii. 30	100–50	1	1	2·79	2·79
362	25. ii. 30	50–0	48	48	2·38–2·96	2·71
		250–100	1	1	2·79	2·79
365	2. iii. 30	50–0	2	2	2·96–3·00	2·98
		250–100	44	44	2·71–3·33	2·99
		500–250	5	5	2·92–3·17	3·04
378	13. iv. 30	50–0	6	6	2·67–2·96	2·84
		100–50	2	2	2·88–2·92	2·90

Table IX (*cont.*)

Station	Date	Depth m.	No. of larvae	Number measured	Length range mm.	Average length mm.
383	14. iv. 30	100–50	23	23	2·50–2·96	2·71
		250–100	80	20	2·75–3·13	2·95
477	12. xi. 30	100–50	1	1	2·71	2·71
618	18–19. ii. 31	50–0	160	31	2·13–2·67	2·41
		100–50	21	21	2·17–2·63	2·41
620	19–20. ii. 31	750–500	1	1	2·50	2·50
		1000–750	1	1	2·38	2·38
622	20. ii. 31	100–50	1	1	2·58	2·58
635	5. iii. 31	50–0	6	6	2·46–2·79	2·60
		100–50	6	6	2·33–2·63	2·49
		250–100	2	2	2·25–2·67	2·46
636	8. iii. 31	250–100	3	3	2·38–2·46	2·42
		500–250	4	3	2·50	2·50
639	9. iii. 31	50–0	1	1	2·67	2·67
		100–50	39	33	2·38–2·92	2·58
		250–100	25	22	2·21–2·83	2·52
		500–250	1	1	2·21	2·21
		750–500	1	1	2·88	2·88
646	11. iii. 31	250–100	1	1	2·67	2·67
		500–250	4	4	2·63–2·71	2·67
647	12. iii. 31	50–0	6	6	2·63–2·92	2·74
		500–250	1	1	2·54	2·54
854	20. iv. 32	119–0	5	5	2·75–2·83	2·78
		248–98	1	1	2·92	2·92
855	20. iv. 32	125–0	1	1	3·04	3·04
		125–0	50	10	2·83–3·13	2·94
		280–154	4	4	2·71–3·00	2·88
WS 139	10. ii. 28	500–250	1	1	2·88	2·88
WS 141	13. ii. 28	250–100	1	1	2·75	2·75
WS 173	6. iii. 28	100–50	1	1	2·63	2·63
WS 182	8. iii. 28	250–100	2	2	2·42–2·79	2·61
WS 197	17. iv. 28	250–100	13	13	2·50–2·92	2·67
		500–250	8	8	2·33–2·71	2·56
WS 527	30. iii. 30	250–100	1	1	2·42	2·42

species. The size of the lobes varies with the size of the larvae, being inconspicuous in the very small larvae and large and easily noticeable in the larger specimens. The compound eyes are more distinctly defined but do not project beyond the margin of the carapace. The fibres of the developing luminous organ at the base of the eyes can be distinguished in the posterior region of the ocular mass.

The antennule consists of a three-jointed peduncle with two rudimentary flagella distally, the one rather larger than the other (Fig. 5 *d*). The sensory filaments on the outer flagellum are situated terminally; there are none on the inner flagellum. The antennae and mandibles are as in the previous stage. The first maxilla (Fig. 5 *e*) is also similar to that found in the 1st Calyptopis except that the outer masticatory lobe bears five spines instead of three and the palp is indistinctly two-segmented. The 2nd maxilla and the 1st thoracic appendage are, in form, as in the previous stage.

THIRD CALYPTOPIS

The average lengths of varying numbers of individuals are stated in Table X. The extreme range of size is between 3·17 and 4·83 mm. The range for the largest number (fifty-eight) measured from one sample is between 3·50 and 4·58 mm. The lower limit of length is almost 1 mm. less than that given by Ruud (1932, p. 48), but the upper limit agrees closely with his.

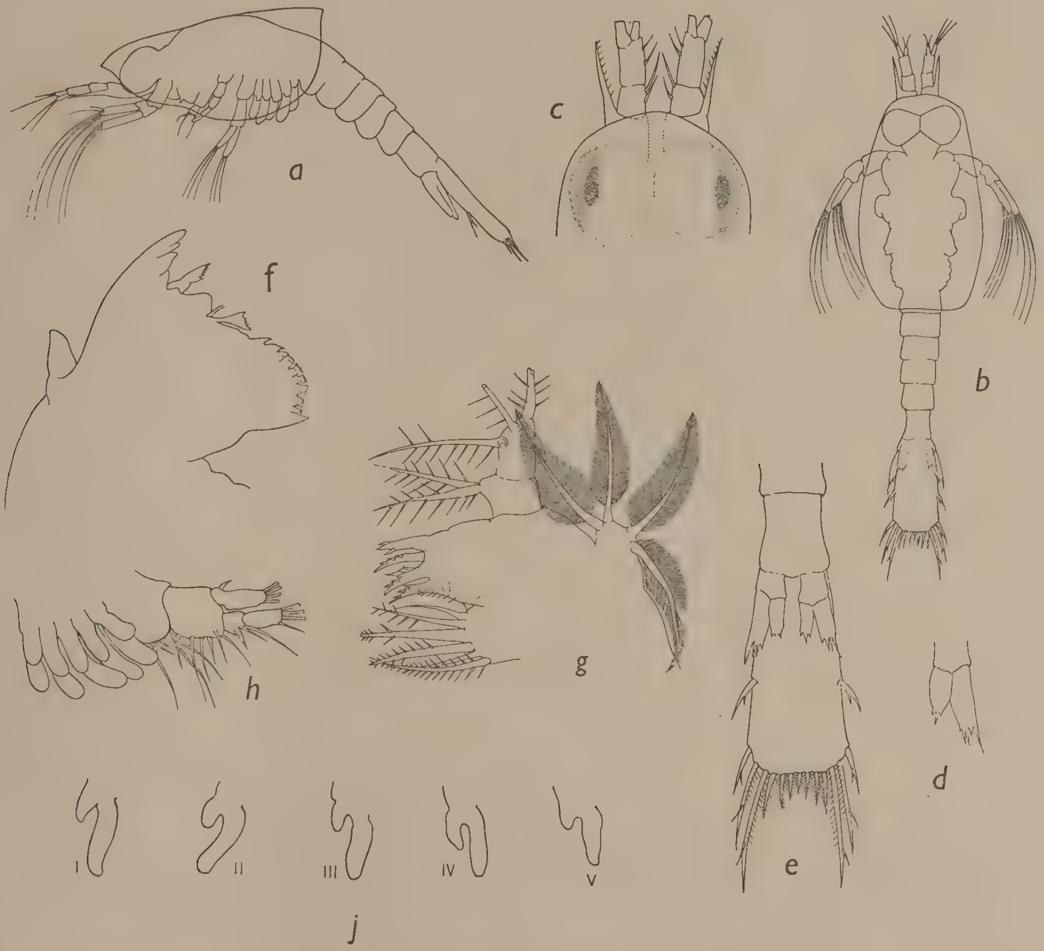

Fig. 6. Third Calyptopis.

a, lateral aspect (× 18);
b, dorsal aspect (× 14);
c, rostrum and antennules, flagella omitted (× 35);
d, uropod (× 46);
e, telson, ventral aspect (× 35);
f, mandible (× 165);
g, first maxilla (× 110);
h, first thoracic limb with limbs II–VI *in situ* (× 35);
j, thoracic limbs II–VI (× 35).

The carapace is without lateral denticles (Fig. 6 *a*). In dorsal aspect (Fig. 6 *b*) it completely covers the compound eyes, which are globular in shape and show traces of pig-

Table X. *Occurrence of Third Calyptopis*

Station	Date	Depth m.	No. of larvae	Number measured	Length range mm.	Average length mm.
161	14. ii. 27	250–100	1	1	3·96	3·96
169	22. ii. 27	500–250	7	7	3·67–4·38	4·00
		750–500	1	1	4·79	4·79
187	18. iii. 27	100–50	1	1	4·17	4·17
193	28. iii. 27	500–250	77	50	4·08–4·79	4·48
		750–500	4	4	4·17–4·46	4·40
194	28. iii. 27	100–50	63	58	3·50–4·58	4·06
		250–100	59	48	3·54–4·42	3·84
		500–250	1	1	4·04	4·04
197	3. iv. 27	50–0	1	1	4·29	4·29
		100–50	7	7	3·96–4·46	4·29
		1000–750	2	1	3·92	3·92
198	3. iv. 27	50–0	34	33	3·83–4·83	4·42
		100–50	3	3	4·25–4·38	4·32
		750–500	1	1	4·42	4·42
		1000–750	1	1	4·17	4·17
199	3. iv. 27	500–250	4	4	4·04–4·58	4·28
		750–500	3	3	4·08–4·21	4·15
202	5. iv. 27	50–0	7	7	4·00–4·33	4·15
		500–250	2	2	4·04–4·25	4·15
203	5. iv. 27	250–100	1	1	3·83	3·83
204	6. iv. 27	500–250	2	2	4·58–4·75	4·67
205	6. iv. 27	215–100	2	2	4·04–4·08	4·06
300	20. i. 30	500–250	15	3	3·58–3·88	3·76
302	21. i. 30	250–100	2	2	3·96–4·17	4·07
		500–250	2	2	3·96–4·04	4·00
303	21. i. 30	500–250	90	50	3·67–4·29	4·01
304	21. i. 30	500–250	22	22	3·63–4·33	4·05
305	21–22. i. 30	100–50	1	1	3·54	3·54
		250–100	1	1	4·29	4·29
313	25. i. 30	250–100	5	4	4·00–4·29	4·10
319	29–30. i. 30	250–100	3	3	3·67–4·17	3·92
320	30. i. 30	500–250	60	40	3·67–4·04	3·87
321	30–31. i. 30	100–50	1	1	3·75	3·75
		1000–750	1	1	3·96	3·96
323	31. i. 30	500–250	5	4	3·54–3·83	3·64
324	1. ii. 30	250–100	1	1	3·50	3·50
		500–250	1	1	3·42	3·42
332	2–3. ii. 30	250–100	3	3	3·54–3·75	3·67
335	4–5. ii. 30	50–0	1	1	3·63	3·63
344	7–8. ii. 30	100–50	1	1	3·54	3·54
345	8. ii. 30	180–100	5	5	3·54–4·08	3·80
356	10. ii. 30	250–100	8	8	4·25–4·54	4·41
357	10. ii. 30	100–50	1	1	3·83	3·83
358	11. ii. 30	50–0	6	6	3·79–3·96	3·88
		100–50	1	1	4·04	4·04
360	24. ii. 30	100–50	1	1	3·79	3·79
361	25. ii. 30	50–0	2	2	3·96–4·38	4·17
		100–50	1	1	3·96	3·96
		250–100	18	9	3·54–4·21	4·03
362	25. ii. 30	50–0	138	50	3·33–4·25	3·78
		100–50	2	2	3·58–4·08	4·33
		250–100	50	50	3·38–4·46	3·94

Table X (*cont.*)

Station	Date	Depth m.	No. of larvae	Number measured	Length range mm.	Average length mm.
365	2. iii. 30	50–0	11	11	4·08–4·75	4·40
		250–100	441	50	4·00–4·75	4·39
		500–250	10	10	4·04–4·79	4·43
368	8. iii. 30	50–0	2	2	3·96–4·38	4·17
		250–100	11	11	4·00–4·33	4·13
		500–250	1*	—	—	—
369	9. iii. 30	50–0	1	1	4·13	4·13
		250–100	12	12	4·08–4·38	4·27
378	13. iv. 30	50–0	1	1	4·17	4·17
383	14. iv. 30	100–50	17	14	3·46–4·17	3·84
		250–100	384	50	3·88–4·58	4·17
618	18–19. ii. 31	50–0	2	2	3·50	3·50
635	7. iii. 31	50–0	9	9	3·17–3·50	3·33
		100–50	2	2	3·29–3·50	3·40
		250–100	1	1	3·25	3·25
636	8. iii. 31	500–250	1	1	3·29	3·29
853	19. iv. 32	119–0	3	3	3·96–4·21	4·07
854	20. iv. 32	119–0	12	7	3·67–3·96	3·84
		248–98	2	2	3·75–3·79	3·77
855	20. iv. 32	125–0	23	23	4·08–4·75	4·35
		125–0	420	50	3·88–4·58	4·27
		280–154	6	6	4·00–4·38	4·11
WS 141	13. ii. 28	500–250	1	1	3·96	3·96
WS 197	17. iv. 28	100–50	1	1	4·17	4·17
		250–100	3	3	3·96–4·17	4·06
		500–250	3	3	3·96–4·13	4·03
WS 198	19. iv. 28	250–100	2	2	4·08–4·17	4·13
		500–250	1	1	4·04	4·04
WS 199	20. iv. 28	500–250	11	11	3·83–4·38	4·13
WS 200	21. iv. 28	500–250	10	10	3·88–4·33	4·10
WS 201	22. iv. 28	50–0	8	8	4·08–4·46	4·25
		100–50	2	2	4·17	4·17
		250–100	1	1	4·04	4·04
WS 527	30. iii. 30	250–100	1	1	3·17	3·17

* Specimen damaged—unmeasurable.

ment. In lateral view the carapace anteriorly is more angular than in the 2nd Calyptopis, and in preserved specimens the eyes may project a very little way beyond its margin. In some of the larger 3rd Calyptopis a clearly defined hyaline area can be distinguished just above each eye in the carapace, a foreshadowing of the emarginations which are present in all later stages.

The abdomen is more elongate than in the 2nd Calyptopis, seven-segmented and longer than the anterior portion of the body. Each uropod (Fig. 6 *d*) consists of a short basal segment bearing two rami, of which the outer is longer than the inner. The outer ramus carries a large spine externally at the tip and two rather small weak spines internally. The inner ramus has a small spine distally. The arrangement of spines at the end of the telson (Fig. 6 *e*) is similar to that of the 2nd Calyptopis.

In the antennule the peduncle consists of three segments, of which the basal is prolonged externally into a strong spine, extending to, or a little way beyond, the distal margin of the distal peduncular segment (Fig. 6 *c*). The flagella are not greatly altered from the form found in the 2nd Calyptopis; the outer flagellum bears two sensory filaments terminally. The antenna, mandible, 1st and 2nd maxilla and the 1st thoracic appendage (Figs. 6 *f*, *g*, *h*) are unchanged.

Behind the 1st thoracic appendages are five pairs of bilobed "sausage-shaped" thoracic rudiments (Fig. 6 *g*). In each limb the endopod is longer than the exopod. The posterior limbs are shorter than the anterior; there is no trace of segmentation or setae on the limbs. In Fig. 6 *h* the 1st thoracic limb has been shown along with the succeeding five limbs to compare the difference in size.

The luminous organ at the base of the eye, recognizable as a bunch of fibres, is the only one that can as yet be distinguished.

SUMMARY OF PREVIOUS KNOWLEDGE RELATING TO THE FURCILIA AND CYRTOPIA STAGES

In the report on the Schizopoda collected by H.M.S. 'Challenger' (Sars, 1885), in the section dealing with development of Euphausiidae, it is stated that the three schizopodous genera, Calyptopis, Furcilia and Cyrtopia of Dana were proved by Claus (1863) to be different stages in the development of Euphausiidae. Metschnikoff (1869, 1871) describes still earlier stages, which Sars in accordance with earlier authors designates the Nauplius and Metanauplius stages. For the three succeeding stages Sars applies the generic denominations suggested by Dana. It is the last two of these stages, namely Furcilia and Cyrtopia, which are to be discussed here. They are described by Sars as follows:

> *Furcilia stage.* Compound eyes more fully developed (than in Calyptopis), mobile, and projecting beyond the sides of the carapace. Antennae still retaining their original structure, natatory. Anterior pairs of legs and pleopoda successively developing.
>
> *Cyrtopia stage.* Antennular flagella becoming elongate and distinctly articulate. Antennae transformed so as not to serve the purpose of locomotion. Posterior legs and gills successively appearing.

Within the division which he terms Furcilia, Sars in his description of *Euphausia pellucida*, Dana (= *E. superba*), recognizes three stages which he names respectively first, intermediate and last Furcilia. Similarly in the Cyrtopia of this species he recognizes two stages, a first and last. The distinction between different stages of both Furcilia and Cyrtopia is based mainly on the degree of development of the appendages.

Referring to the development of *Thysanopoda tricuspidata* Sars states (p. 167) that there are several successive stages of Furcilia in the collection. He only refers to one Cyrtopia stage. In *Nematoscelis rostrata*, G. O. Sars, he recognizes two Furcilia stages and one Cyrtopia.

Brook and Hoyle (1888), describing the metamorphosis of British Euphausiidae, state that in the Furcilia of one species there are eleven moults judging from the comparative development of the pleopods, thus:

Stage 1. No rudiments of pleopods.
2. First pair of pleopods as simple rudiments.
3. Second ,, ,, ,, ,, ,,
4. Third ,, ,, ,, ,, ,,
5. Fourth ,, ,, ,, ,, ,,
6. Fifth ,, ,, ,, ,, ,,
7. First pair of pleopods biramous and setose.
8. Second ,, ,, ,, ,, ,,
9. Third ,, ,, ,, ,, ,,
10. Fourth ,, ,, ,, ,, ,,
11. Fifth ,, ,, ,, ,, ,,

They indicate also that there is more than one Cyrtopia stage, and remark that before the adult stage is reached a large number of ecdyses must take place.

Lebour (1926 *c*) in a paper entitled "A general survey of larval euphausiids, with a scheme for their identification", recognizes a succession of Furcilia forms commencing with that in which no pleopods are present and followed by others during which the pleopods develop successively until all are setose and biramous. It is stated in this paper that "the pleopods develop in different ways in several different genera, of which the first three or four (forms) are the same and the last two or three are the same, but in between there are different orders of development some of which appear to be characteristic of certain genera". In *Thysanoessa*, for instance, all five pleopods are simple buds before any are setose. In *Euphausia krohnii* the first is setose whilst four are simple. The commonest group found, it is stated, is one which occurs in five genera—*Nyctiphanes*, *Meganyctiphanes*, *Thysanopoda*, *Euphausia*, and *Nematoscelis*—in which the first pleopod is setose with the three following simple and the last not yet formed. In all the genera with the exception of *Euphausia* the second pleopod becomes setose before the last bud appears. Finally in *Stylocheiron* the first pleopod is setose with only two buds behind. This paper later states that the distinctive stages nearly always seem to occur as though certain stages were dominant. Thus in *Stylocheiron* it is Furcilia 7, that is, according to the pleopod development, a form having three pairs of pleopods one pair of which is setose. In *Thysanoessa* it is Furcilia 6, that is, a form having five pairs of non-setose pleopods. In *Euphausia krohnii* it is Furcilia 9, a form in which the pleopod arrangement is one pair setose and four pairs simple. Lebour's paper draws attention to the jumping of stages in some species; it is stated that "Mr Elmhirst and Mr Macdonald from Millport tell me that *Meganyctiphanes* may jump several stages but they always jump into a stage known for that genus. Mr Elmhirst has provided me with some notes on *Meganyctiphanes* (reared in aquaria) in which one jumped from one to three pairs of simple pleopods and one which jumped from three pairs of simple pleopods to three pairs setose and two pairs simple."

Macdonald (1927 *b*, p. 785), in his paper on "Irregular development in the larval history of *Meganyctiphanes norvegica*", states that the Furcilia is to be recognized by having the eyes no longer covered by the carapace and by the appearance of the pleopods. He distinguished eleven stages of Furcilia, certain of which tended to be dominant and others to be suppressed. He also found that "those Furcilia stages which were observed to be sometimes omitted during development in captivity were less frequent in the plankton than the other Furcilia stages". "On the other hand", he states, "there were certain stages which predominated in numbers in the plankton." The graph of the frequency of distribution of his eleven Furcilia stages for 302 larvae shows a distinctly bimodal curve, having the one maximum at stage 4 (i.e. three pairs of simple pleopods) and the second at stage 9 (three pairs of setose pleopods and two pairs simple). It is also interesting in this paper to note that of twenty-six larvae kept in aquaria more than half moulted irregularly.

Attention is drawn by Macdonald to further evidence of curtailed larval history provided by another euphausiid, *Nematoscelis microps*, writing of which Lebour states (1926 *d*, p. 766): "The youngest stage found is presumably the second furcilia, measuring 2·4 mm. in length and having one pair of simple bud-like pleopods....The next seen has one pair of pleopods setose and three pairs simple. It is striking that these stages, together with the tenth,[1] seem to be dominant, as no intermediate stages were found whilst these were abundant. Moreover, the sixth and tenth are the stages described by Sars."

Again, on p. 770 Lebour states with reference to *Euphausia krohnii*: "Sars describes the second and seventh furcilia[2] having one pair of simple pleopods, and one pair setose and four pairs simple respectively. No stages between these two have been found in the Alexandria samples." "The Furcilia with all pleopods setose is presumably the last."

On pp. 768 *et seq.* of this paper on euphausiids from the Mediterranean, Lebour describes the larvae of *Thysanopoda aequalis*, Hansen. "The first furcilia", she states, "the earliest stage seen, measures 2·6 mm. in length. It has no pleopods. The next stage present, measuring 2·9 mm. in length, is probably the third Furcilia having two pairs of simple pleopods. Then apparently several stages are absent and the next seen, measuring 3·5 mm. and probably the seventh Furcilia, has two pairs of setose pleopods and two pairs simple." The following Furcilia stage (text-fig. 2, p. 769) is that in which there are four pairs of setose pleopods and the last pair non-setose.

Rustad (1934, p. 15) shows that in *Euphausia frigida* the Furcilia stages 5, 13 and 14 of Lebour's pleopod diagram are the only ones to be found; these stages are, respectively, forms having four pairs of non-setose pleopods, four pairs setose and one pair non-setose, and all five pairs setose. In the same publication, under *Thysanoessa macrura*, G. O. Sars, and *Th. vicina*, Hansen (the two species are not separated), Rustad states that he found numbers 1, 6 and 14 of the Furcilia stages of Lebour, representing larvae having respectively no pleopods, five pairs of non-setose, and five pairs setose.

Lebour suggests the dominance of certain stages in her earlier paper (1926 *c*) and demonstrates it in the species *Nematoscelis microps*, *Euphausia krohnii* and *Thysanopoda aequalis* (1926 *d*). Macdonald shows that in a sample of *Meganyctiphanes norvegica*, where eleven different Furcilia forms occur, two stages are dominant, set apart from one another by an interval of several intermediate stages.

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[1] The tenth stage referred to is the tenth for this species, not the tenth stage of Lebour's scheme. The pleopod arrangement is four pairs setose and one pair non-setose.

[2] The seventh stage here is the 9th Furcilia stage of Lebour's scheme.

It has escaped notice that of the stages which are dominant in the six species just mentioned, the earlier dominant stage bears a direct relationship to the later. This relationship is significant in the consideration of *Euphausia superba* which follows.

The less advanced dominant stage becomes in each species the more advanced by the provision of setae on the non-setose pleopods present in the earlier stage and the addition of one or more pairs of non-setose pleopods. In other words, each pleopod appears first in the non-setose form, and is provided with setae at the next ensuing moult. Thus, in *Nematoscelis* as indicated in Fig. 7 below, the one pair of simple pleopods gives rise to a form having one pair of setose pleopods and three pairs simple, and in the next conspicuous stage these three simple become setose and one non-setose pair is added. A similar method of development takes place in *Euphausia krohnii*, *Thysanopoda aequalis*, *Euphausia frigida* and *Thysanoessa macrura* and *vicina*. *Meganyctiphanes norvegica* shows by its dominant stages that a similar process of development is taking place in it also, for the first dominant stage, that having three pairs of non-setose pleopods, is followed by one having three pairs setose and two pairs non-setose.

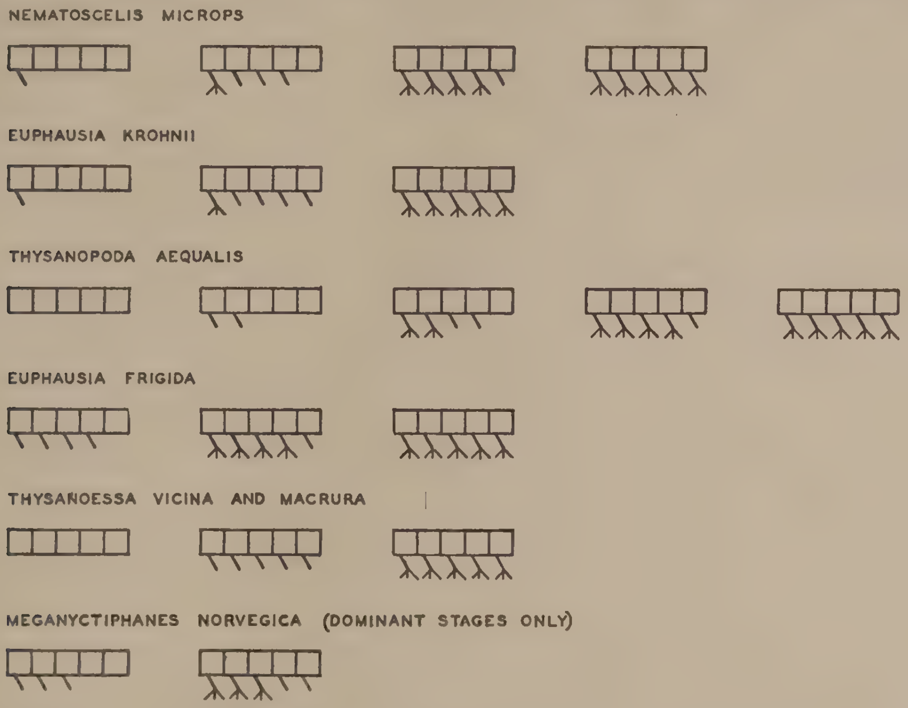
NEMATOSCELIS MICROPS
EUPHAUSIA KROHNII
THYSANOPODA AEQUALIS
EUPHAUSIA FRIGIDA
THYSANOESSA VICINA AND MACRURA
MEGANYCTIPHANES NORVEGICA (DOMINANT STAGES ONLY)

Fig. 7. Diagram to show the relationship of pleopod development and successive dominant stages. In euphausians where the development is known the pleopods appear first in the non-setose form and become setose in the ensuing dominant stage.

In a very recent paper by Frost (1935) there is still further evidence of a succession of early Furcilia stages in which non-setose pleopods become setose in the next ensuing moult. The pleopod arrangement in *Nematoscelis megalops* is: Two pairs non-setose—two pairs setose, three pairs non-setose—all five pairs setose. In *Stylocheiron longicorne* it is: no pleopods—one pair non-setose—one pair setose, two pairs non-setose—three pairs setose, two pairs non-setose—all five pairs setose. Thus in each instance where the number of pleopods at any stage is known it is possible to predict the number of setose pleopods after the next ensuing moult.

EARLY FURCILIA STAGES

Turning now to *Euphausia superba* in the samples used for the identification of Furcilia stages, namely those from 70-cm. nets covering a number of seasons, and from the oblique nets of the circumpolar cruise, fourteen different forms of Furcilia are recognizable by the variation of development in the pleopods.

These forms and their frequency of occurrence are shown in the table below, in which is expressed the number of stations at which the various Furcilia forms were found.

		Number of Stations at which the form was found
(1)	No pleopods	1
(2)	2 pairs of simple pleopods	1
(3)	3 „ „ „	5
(4)	4 „ „ „	23
(5)	5 „ „ „	39
(6)	3 „ pleopods, 2 setose, 1 non-setose	1
(7)	4 „ „ 1 „ 3 „	1
(8)	4 „ „ 2 „ 2 „	1
(9)	4 „ „ 3 „ 1 „	1
(10)	4 „ „ all setose	2
(11)	5 „ pleopods, 2 setose, 3 non-setose	1
(12)	5 „ „ 3 „ 2 „	2
(13)	5 „ „ 4 „ 1 „	12
*(14)	5 „ „ all setose, *A* and *B* forms	45

* In this form there are two types of larva recognizable: *A*, a smaller less developed form which normally moults again into *B*, and *B*, larger and more developed and generally moulting into a form with five terminal spines on the telson.

Of the fourteen different Furcilia identified seven occur at one station only, and for six of them the station is the same, namely WS 527. The remaining forms are found at varying numbers of stations, but it will be noted that those occurring at the greatest number of stations are as follows: (1) forms having four or five pairs of non-setose pleopods, and (2) forms having four pairs of setose pleopods and one pair non-setose or all five pairs setose. In other words these are dominant forms comparable to those in *Meganyctiphanes* described by Macdonald.

Analyses of the plankton samples taken with vertical 70-cm. nets at St. WS 527 show that *Euphausia superba* larvae were present in a variety of forms, stated in Table XI below. The number of different kinds of larvae and the frequency of occurrence are shown and the average length of each stage is given. For completeness there have been included Calyptopis stages and Furcilia stages with reduced numbers of spines terminally on the telson, but it is the earlier Furcilia forms up to the point where five pairs of pleopods, all setose, are found which are to be discussed here. Within these limits thirteen different kinds of Furcilia occur. As in the frequency expressed by the number of stations at which they were present, so here, by the frequency of individuals, two maxima are recognizable: (1) larvae having four or five pairs of non-setose pleopods, and (2) larvae having either four pairs setose and one pair non-setose, or all five pairs setose. These are represented in far greater abundance than other combinations of setose and non-setose pleopods and are the dominant stages.

Table XI. Euphausia superba *larvae from St. WS* 527

	Numbers of larvae				Average length mm.
	50–0 m.	100–50 m.	250–100 m.*	Total	
2nd Calyptopis	—	—	4	4	2·42
3rd Calyptopis	—	—	4	4	3·17
Furcilia with no pleopods	—	—	8	8	3·50
,, 2 pairs of non-setose pleopods	—	—	4	4	3·88
,, 3 pairs of non-setose pleopods	—	—	8	8	3·81
,, 4 pairs of non-setose pleopods	—	—	36	36	4·37
,, 5 pairs of non-setose pleopods	—	—	20	20	4·55
,, 3 pairs of pleopods, 2 setose, 1 non-setose	—	—	8	8	4·00
,, 4 pairs of pleopods, 1 setose, 3 non-setose	—	—	4	4	4·58
,, 4 pairs of pleopods, 2 setose, 2 non-setose	—	—	4	4	4·58
,, 4 pairs of pleopods, 3 setose, 1 non-setose	—	—	4	4	4·50
,, 5 pairs of pleopods, 3 setose, 2 non-setose	—	2	4	6	4·81
,, 4 pairs of pleopods, all setose	—	—	32	32	4·84
,, 5 pairs of pleopods, 4 setose, 1 non-setose	—	4	116	120	5·06
,, 5 pairs of setose pleopods. Smaller, Form *A*	8	10	224	242	5·58
,, 5 pairs of setose pleopods. Larger, Form *B*	12	1	16	29	6·65
,, 6 terminal spines	4	—	—	4	7·38
,, 5 terminal spines	80	2	—	82	7·79
,, 1 terminal spine	8	—	—	8	10·19

* In this sample only a quarter of the total was analysed.

Inspection of the varying forms of pleopod found amongst the Furcilia at this station shows that without retrogression in development, either in the number of pleopods or in the formation of setae, the larvae cannot moult successively into all the different forms found. Thus those with four or five pairs of non-setose pleopods cannot moult into forms having three pairs of pleopods, two pairs of which are setose and one pair non-setose, without diminishing the number of pleopods. Or if this three-pleopod form be considered less advanced than that having four or five pairs of non-setose pleopods, it cannot moult into one of these latter forms without losing the setae on the first two pairs of pleopods. For the same reasons larvae having two pairs of setose and one pair of non-setose pleopods cannot follow or be followed by forms having one pair setose and three pairs non-setose, nor can larvae having four pleopods, all setose, follow or be followed by forms having five pleopods, three pairs of which are setose and two non-setose.

Anatomical examination of these larvae shows that the progress of development cannot be through a series in which at first non-setose pleopods are successively added, and then by these becoming setose until five setose pleopods result. On the contrary practically every one of the larvae having non-setose pleopods has within the integument the rudiments of setae, so that larvae having two pairs of non-setose pleopods would on moulting become forms having two pairs of setose pleopods and presumably one, two, or three pairs of non-setose pleopods. Larvae with three pairs of non-setose pleopods on moulting become larvae having three pairs of setose pleopods and one or two pairs non-setose, and so on. Thus one would expect to find that the relative abundance of the different kinds of non-setose larvae would be reflected in the setose section and this is what actually happens, for scarce forms such as those with two or three pairs of non-setose pleopods are represented by equally scarce setose forms with two or three pairs setose and one or two pairs non-setose. Likewise those with four or five pairs of non-setose pleopods, which occur abundantly, are followed by equally abundant forms having four pairs setose and one pair non-setose or all five pairs setose.

The suggestion that the larvae moult from forms with non-setose pleopods directly into forms in which those pleopods are setose is supported by the frequency distribution of larvae at stations where a large number occur in the samples. Table XII below shows the larvae from such stations classified according to the condition of the pleopods. The Calyptopis have been included to show that by far the greater number of larvae moult from the third Calyptopis into such as have four or five pairs of non-setose pleopods, and then into larvae having five pairs of setose pleopods or four pairs setose and one pair non-setose.

It is fair to conclude then that in *Euphausia superba* the progress of Furcilia development is from forms in which four or five non-setose pleopods become directly changed on ecdysis into larvae recognizable by having the four or five pairs of non-setose pleopods changed into setose pleopods, and in the former alternative by the addition of one pair of non-setose pleopods. Smaller numbers of non-setose pleopods should be regarded merely as variations of the dominant numbers and, likewise, other combinations of setose and non-setose pleopods should be regarded as infrequently occurring variants of the later dominant form. Thus up to the point when the Furcilia has five pairs of setose pleopods only two Furcilia stages of *E. superba* are recognizable.

INTERPRETATION OF DOMINANT STAGES

Comparing what happens in *E. superba* with what has been observed in *Nematoscelis microps*, *Euphausia krohnii*, *E. frigida*, *Thysanopoda aequalis*, *Meganyctiphanes norvegica*, *Thysanoessa macrura* and *Th. vicina*, I would suggest that the stages recognized as dominant in these species should be regarded as actual stages of that part of the developmental history. Thus in *Nematoscelis microps* the stages referred to as 2nd, 6th and 10th, based on the successive addition of pleopods and by these becoming setose, should be regarded as stages 1, 2 and 3, and so with the other species mentioned above, except *Meganyctiphanes*, in which conditions are somewhat different. In this last-mentioned genus Macdonald, as already stated, recognized eleven Furcilia, but of these the Furcilia having three pairs of non-setose pleopods and that having three pairs setose and two pairs non-setose are dominant. On analogy with what happens in *Euphausia superba*, particularly with respect to the larvae from St. WS 527, I think it reasonable to suggest that these two "dominant" forms are in fact the first two Furcilia stages, that stages identified by having no pleopods, one pair, two pairs and three pairs of simple pleopods are variants of the early stage and that the remainder with setose pleopods are variants of the 2nd stage.

Table XII. *Frequency of occurrence of larvae of varying form at stations where representative samples were taken*

Station	Calyptopis			Furcilia																Total
				Pairs of pleopods													Apex of telson			
	First	Second	Third	None	2 simple	3 simple	4 simple	5 simple	2 setose, 1 simple	1 setose, 3 simple	2 setose, 2 simple	3 setose, 1 simple	3 setose, 2 simple	4 setose	4 setose, 1 simple	*A.* 5 setose;	*B.* 7 spines	6 spines	5 spines	
193	—	12	81	—	—	—	—	26	+	—	—	—	—	—	—	—	1	—	—	120
194	6	46	123	—	—	—	2	13	+	—	—	—	—	—	—	—	1	—	—	191
198	1	28	39	—	—	—	—	4	+	—	—	—	—	—	2	—	9	—	5	88
303	—	34	90	—	—	—	—	7	+	—	—	—	—	—	—	2	—	—	—	133
304	—	2	22	—	—	—	—	4	+	—	—	—	—	—	—	—	2	—	—	30
305	2	11	2	—	—	—	—	1	—	—	—	—	—	—	—	1	—	—	—	17
320	1	29	60	—	—	—	5	4	—	—	—	—	—	—	—	—	—	—	—	99
332	5	2	3	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	11
361	—	1	12	—	—	—	1	80	—	—	—	—	—	—	—	74	8	—	1	177
362	—	49	190	—	—	—	4	90	—	—	—	—	—	—	—	9	2	—	—	344
365	—	51	462	—	—	—	—	192	—	—	—	—	—	—	—	4	—	—	—	709
368	—	—	14	—	—	—	15	22	—	—	—	—	—	—	—	14	1	—	—	66
369	—	—	13	—	—	—	14	12	—	—	—	—	—	—	—	9	2	—	—	50
383	146	43	401	—	—	—	5	132	—	—	—	—	—	—	—	—	—	—	—	727
635	—	12	11	—	—	2	5	4	—	—	—	—	—	—	—	1	—	—	—	35
636	32	4	1	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	39
WS 199	—	—	11	—	—	—	—	31	—	—	—	—	—	—	—	17	3	—	—	62
WS 200	—	—	10	—	—	—	—	79	—	—	—	—	—	—	—	52	13	—	—	154
WS 201	—	—	11	—	—	—	4	9	—	—	—	—	—	—	1	3	1	—	—	29
WS 527	—	4	4	8	4	8	36	20	8	4	4	4	6	32	120	242	29	4	82	619

The institution by the early writers of a succession of Furcilia stages, recognized by the addition of pleopods commencing with the pair on the first abdominal segment and later by the provision of setae on these pleopods, is apparently based neither on direct evidence of moulting nor (until Macdonald's work on *Meganyctiphanes*) on any quantitative analysis of the material. The result of Macdonald's quantitative investigation has already been stated, and his observations of moulting show that more than half do so "irregularly"; of the remainder which moult "regularly" he does not indicate from which stage they moult. Whatever they are, the evidence they provide, in conjunction with the "irregularly" moulting individuals, shows in the clearest way that in this species development is not by a well-defined progression of stages in which pleopods are successively added.

It may be well here to quote Rustad (1930, p. 45) in his description of the larval stages of *Euphausia frigida* and *Thysanoessa macrura*. He says: "Development seems to proceed rather schematically up to and including the Calyptopis stages. From the Furcilia stage and upwards it seems on the other hand that there is greater room for action of individual variation. Certainly we observe a clearly pronounced main line which finally leads up to the fully developed adults, but it is impossible to demonstrate any absolute or fixed relation in degree of development between the different organs, and each 'stage' therefore covers a rather broad range of variation in degree of development and form of the single appendage or organ." These remarks should be borne in mind, for they are equally applicable to the development of *Euphausia superba* both with regard to the Furcilia stages already discussed and those which are to be considered in the next section.

Macdonald (1927 *b*) quoting Gurney (1924) states that "Among Crustacea, continuous larval development is a primitive feature, whereas a marked metamorphosis is characteristic of more highly developed forms." For this reason Macdonald says "the above observations are interesting as they suggest tentative steps in an evolutionary progress in the order Euphausiacea towards reduction in the number of larval stages. They also suggest that in those arthropods in which the life history consists of a few pronounced stages these are to be regarded not as having evolved independently from a continuous life history, but rather as the survivors of a once greater number of successive stages."

In the light of the evidence provided by *Euphausia superba* and the interpretation of known larval histories in relation to this I consider that it is misleading to talk of a tentative reduction in the *number* of larval stages. This conception is based on the assumption that each variety of pleopod development found indicates a larval stage. It implies that as a primitive phase in the evolutionary history of this group the larvae went through this succession of numerous well-marked changes in form, which is of course contrary to the idea of continuous development. In primitive development one would expect to find no well-marked coincidence of ecdysis with a fixed degree of development. Metamorphosis, as already stated, is a characteristic of highly developed forms. The Euphausiacea should be regarded as coming somewhere between the two extremes, they are arthropods in which "continuous" development is giving way to metamorphosis—already well defined in the Nauplius, Metanauplius and Calyptopis stages, less well defined in early Furcilia by the presence of dominant forms, and still less intelligible in later development. This developing metamorphosis is not essentially a reduction in the *number* of successive stages, but is being brought about by the larvae tending to moult into forms showing a certain degree of development in preference to a lesser or a greater degree.

Continuous development is not an altogether appropriate term to apply to the development of any arthropod, since the course of development is in all cases marked off into stages by the occurrence of ecdyses between which no marked change in form usually occurs. Where ecdyses are numerous and the morphological changes occurring at each are slight, the development is of the type to which the term "continuous" has been applied. Where ecdyses are reduced in number while the total change to be achieved remains the same, the amount of change at each moult will obviously increase till it may reach a degree deserving the name "metamorphosis".

Larval specializations requiring elaboration of the straightforward course of development may further increase the extent of change that has to be accomplished at a single moult.

There is a further consideration to which attention may here be drawn. In the more specialized forms with fewer ecdyses the position of each moult on the scale of development, and therefore the changes occurring at each, becomes as it were standardized. In the more primitive cases with so-called "continuous" development the position of the moult may vary, and the changes effected at each are not always identical. The series of moults may, in fact, be regarded as a kind of "grid" superposed on a course of actually continuous development. In the more primitive cases this grid may still shift slightly backwards and forwards; in the more specialized cases the "grid" has become fixed and all individuals show the same changes at each moult.

INTERMEDIATE FURCILIA STAGES

In Table XII above it is indicated that there are two different forms of larvae having all pleopods setose and having seven terminal spines. Examination of the appendages of these Furcilia shows that there is a very great amount of variation in the degree of development. This is most noticeable in the mandibular palp and 1st thoracic limb. There are also differences in size in the antennular flagella, in the postero-lateral spines of the telson and in the shape of the rostrum and telson.

Nine selected larvae of differing sizes from one sample were examined to discover the range of variation occurring in the mandibular palp, 1st thoracic limb and telson. It was seen that the mandibular palp varied between the small bud-like process typical of earlier stages and an elongated three-segmented setose appendage not unlike that found in the adult. The endopod of the 1st thoracic limb could be from twice to three times as long as the exopod and be composed of from two to five segments. The innermost postero-lateral spine on the telson varied in the breadth of the proximal portion; in the smaller larvae the base of the spine was narrow, in the larger ones it was broadened.

It is possible in some of the larvae to determine the number of terminal spines which are to be present when the larva moults (cf. Macdonald, 1928, pl. iv, fig. 10) and it is found that some are to be seven-spined and others five-spined. Before ecdysis the soft tissues draw away from the enclosing integument, and in the telson region particularly the form of the succeeding stage is defined. It cannot be stated for certain in all the larvae, but in those where it is possible the length frequency distribution correlated with the number of spines in the succeeding stage indicates that the smaller forms clearly tend to moult into larvae, which again have seven spines, while the larger ones moult directly into five-spined forms. This is shown in Table XIII for two samples of seven-spined larvae.

Table XIII. *Length frequencies of larvae with seven terminal spines, arranged according to the number of spines which will be present in the following stage*

Length classes mm.	Following stage				Total
	7-spined	5-spined	6-spined	Uncertain	
5·00–5·24	2	—	—	—	2
5·25–5·49	7	—	—	—	7
5·50–5·74	1	1	—	—	2
5·75–5·99	2	1	1	2	6
6·00–6·24	2	—	—	1	3
6·25–6·49	1	2	—	6	9
6·50–6·74	—	10	1	11	22
6·75–6·99	1	8	—	7	16
7·00–7·24	—	16	—	3	19
7·25–7·49	—	4	—	—	4
7·50–7·74	—	2	—	—	2

There is a considerable overlap in the size ranges of the two groups of larvae in which the number of spines in the succeeding stage can be determined. The normal reduction of the number of terminal spines proceeds by the disappearance of the two outermost, and larvae having six spines should be regarded as exceptional.

The nine larvae mentioned above, when arranged in order of increasing development of the appendages (Fig. 8), furnished a rough scale which was used in the analyses of the samples of seven-spined larvae recorded in Tables XIV and XV. These samples were examined to discover what correspondence, if any, exists between size, degree of development and the numbers of terminal spines in the telson subsequent to moulting. The letters *a* to *j* in the columns of the analyses indicate the form of appendage of the nine larvae which that of the larva in the sample most closely resembled, *a* being the least and *j* the most developed.

In Table XIV the results of an examination of thirty-one larvae are given. It is seen that the rostrum, although it may have a spine in quite small individuals, is in these more often without, whereas in larger larvae there is a greater proportion with a spinous rostral plate. The antennular flagellum increases in length with increasing size of larva. The degree of development of the mandibular palp, 1st thoracic leg and telson within broad limits also correspond with the size of the larva. Here again the fact is demonstrated that smaller larvae moult into seven-spined forms, the larger into five-spined forms, but that there is a great amount of overlapping in size and degree of development.

Table XV shows a similar analysis of larvae from St. 639. The average size of the larvae here is much less than at the previous station cited, and in correlation with this, development is much less advanced; nearly all the larvae indicate that in the following stage they will be seven-spined.

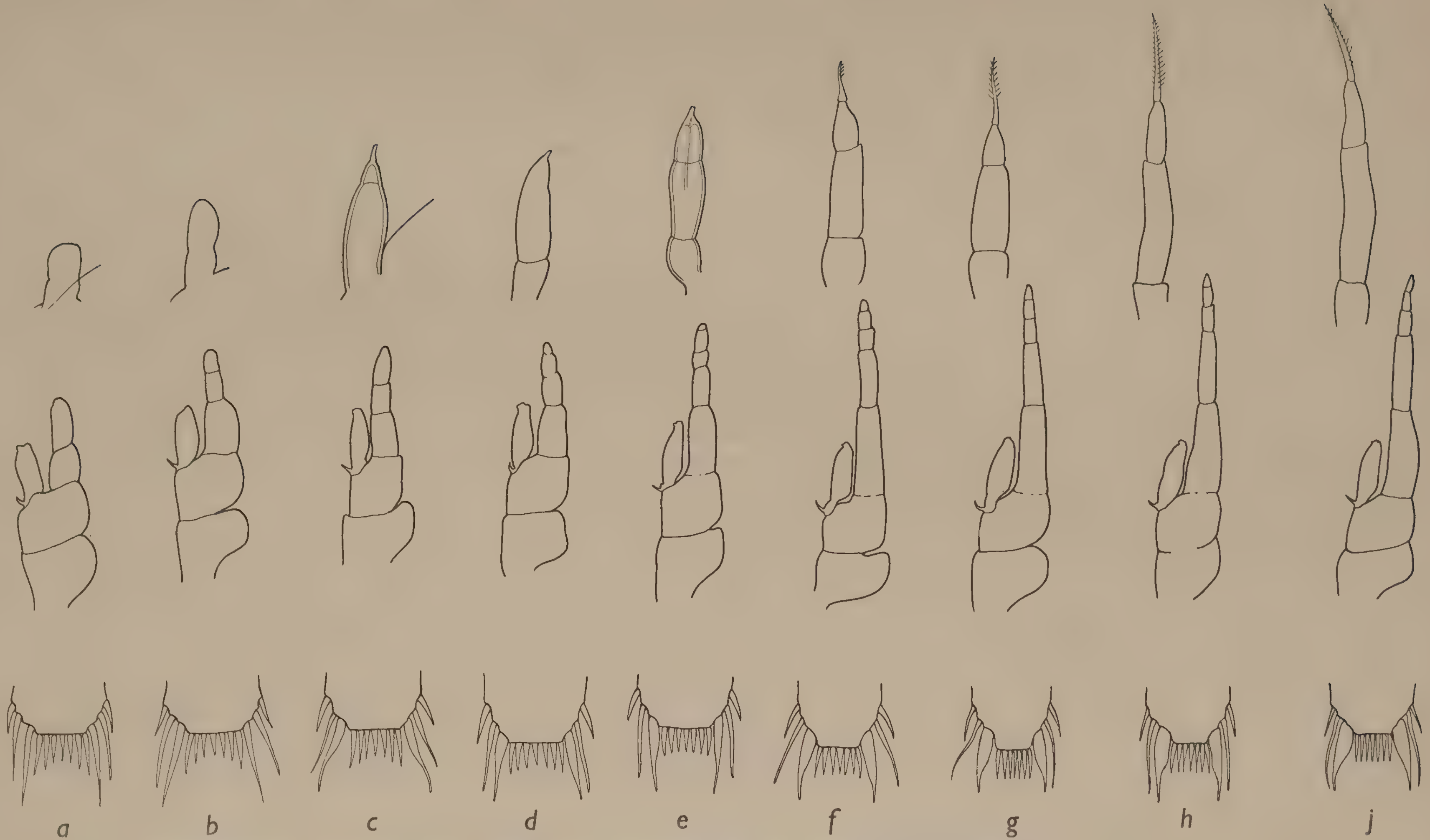

Fig. 8. Appendages of nine selected larvae having seven terminal spines on the telson. The larvae were in length respectively: *a*, 6·04 mm.; *b* and *c*, 6·50 mm.; *d*, 6·71 mm.; *e*, 6·91 mm.; *f*, 6·96 mm.; *g*, 7·04 mm.; *h* and *j*, 7·25 mm. The figures in the upper row are of the mandibular palp, those in the middle row the first thoracic limb and those in the bottom row the telson.

Table XIV. *Analysis of larvae with seven terminal spines on the telson from St. 374*

Length mm.	Rostral spine	Length of antennular flagellum		Form of			Telson No. of spines in succeeding stage	Remarks
		mm.	Micro units	Mandibular palp	1st thoracic leg	Telson		
5·08	0	0·19	4·5	*a*	*b*	*a*	7	
5·08	0	0·25	6	*b*	*b*	*a–c*	7	
5·29	0	0·21	5	*b*	*b*	*a*	7	
5·29	0	0·21	5	*b–c*	*b*	*a*	7	
5·42	0	0·21	5	*a*	*b*	*a*	7	
5·71	0	0·25	6	*c*	*d*	*b–c*	5	Note 1
5·88	0	0·31	7·5	*c*	*d*	*d*	6	Note 2
5·88	+	0·36	8·5	*f*	*f*	*f*	5	Note 1
6·17	0	0·33	8	*d*	*e*	*d–e*	7	
6·29	0	0·42	10	*g*	*e*	*e*	7?	
6·33	0	0·42	10	*h*	*h*	*h*	7?	
6·50	0	0·33	8	*c–d*	*e*	*e*	6	Note 3
6·50	0	0·54	13	*g*	—	*f*	7?	
6·50	0	0·42	10	*h*	*h*	*h–j*	7?	
6·66	0	0·40	9·5	*f*	*g*	*g*	7?	
6·66	+	0·46	11	*g*	*g*	*g–h*	5	Note 4
6·71	+	0·46	11	*f*	*f*	*f*	7?	
6·75	+	0·46	11	*f*	*f*	*f*	7?	
6·79	+	0·42	10	*d*	*e*	*f*	5	
6·79	0	0·50	12	*g*	*h*	*f*	7	
6·79	+	—	—	*g*	*g*	*g*	7?	
6·92	+	0·54	13	*h–j*	*h–j*	*j*	5	
7·00	+	0·50	12	*g*	*g*	*f–g*	7?	Note 5
7·00	0	0·52	12·5	*g*	*h*	*h*	5	
7·00	0	0·50	12	*h*	*h*	*h*	7?	
7·08	0	0·50	12	*f–g*	*g*	*g*	5	Note 4
7·08	0	—	—	*h–j*	*h–j*	*h–j*	5	
7·08	+	0·58	14	*j+*	*j+*	*j*	7?	Note 6
7·46	0	0·58	14	*h–j*	*h*	*h–j*	5	
7·50	0	0·58	14	*j*	*h–j*	*h–j*	5	
7·58	0	0·58	14	*j*	*j*	*j*	5	

The letters *a–j* in columns 5–7 afford reference to the nine larvae (Fig. 8), which were arranged according to increasing development of their appendages.

Note 1. The two specimens measuring 5·71 and 5·88 mm. respectively will definitely have a five-spined telson in the succeeding stage, although they are of small size and have the less developed appendages generally found in larvae which will again moult into a seven-spined form.

Note 2. Into the outermost left-hand terminal spine of the telson there projects a very thin filament, whilst the corresponding spine on the right side has projecting into its interior a definite process similar to those found within the remaining spines.

Note 3. There will be six well-developed spines in the next stage, the projection into the outermost right-hand spine being completely absent.

Note 4. Within the integument of the telson there are definite projections into five of the terminal spines. The outermost spines on each side have tiny processes projecting into them. The latter would probably atrophy and the succeeding stage would almost certainly be five-spined.

Note 5. The outermost spines have processes projecting into them which are almost as well defined as the others, but preparation for the following stage has not gone far enough to say whether the succeeding stage will be seven- or five-spined.

Note 6. The formation of seven spines is indicated within the integument of the existing terminal spines, but the outermost on each side is much less robust than the remaining five and would possibly have degenerated before the larva moulted.

Table XV. *Analysis of larvae with seven terminal spines on the telson from St.* 639

Length mm.	Rostral spine	Length of antennular flagellum		Form of			Telson. No. of spines in succeeding stage	Remarks
		mm.	Micro units	Mandibular palp	1st thoracic leg	Telson		
5·46	0	0·21	5	*a*	*a*	*a*	7	
5·91	0	0·25	6	*a*	*a*	*a*	7	Note 1
6·00	0	0·27	6·5	*a*	*a*	*a–b*	7	
6·08	0	0·25	6	*a–b*	*a–b*	*a–b*	7	
6·08	0	0·29	7	*a–b*	*a*	*a–b*	7	
6·12	0	0·29	7	*b*	*a*	*a–b*	7	
6·13	0	0·29	7	*a–b*	*a*	*a*	7	
6·21	0	0·27	6·5	—	*a*	*a–b*	7	
6·21	0	0·27	6·5	*b*	*a*	*a–b*	7	
6·25	0	0·31	7·5	*b*	*a*	*a–b*	7	
6·25	0	0·31	7·5	*b*	*a*	*a–b*	7	
6·25	0	0·29	7	*b*	*a*	*a–b*	7	
6·38	+	0·29	7	*b*	*a*	*a–b*	7 ?	
6·46	+	0·42	10	*f*	*e*	*d–e*	7 ?	
6·75	+	0·38	9	*g*	*d*	*d–e*	7	

The letters *a–j* in columns 5–7 afford reference to the nine larvae (Fig. 8), which were arranged according to increasing development of their appendages.

Note 1. The 5th pleopods are non-setose.

Table XVI gives the results of examination of sixty-one seven-spined larvae from St. 374. In addition to the degree of development as in the two previous tables, the lengths of the mandibular palp, 1st thoracic appendage, and inner antennular flagellum are given both in millimetres and in the units (24 units = 1 mm.) actually employed in measurement.

The length frequency of all the seven-spined larvae from St. 374 is given in Table XVII, in which also is shown the number of specimens which will have seven and five spines in the succeeding stage. The results are shown graphically in Fig. 9.

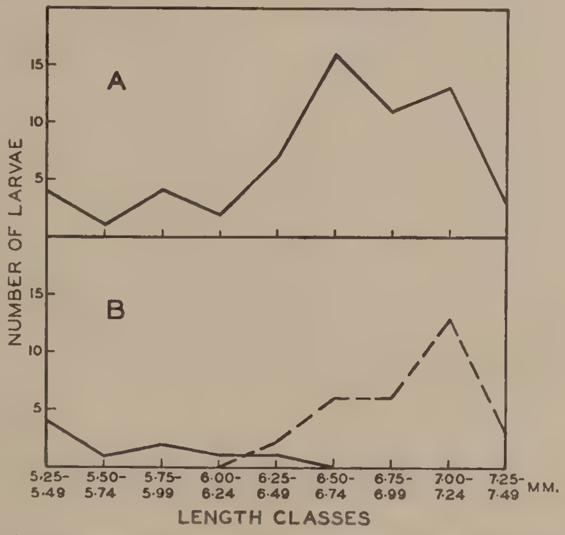

Fig. 9. Length frequency of seven-spined larvae from St. 374. *A*, all the seven-spined larvae. *B*, seven-spined larvae in which the telson form in the succeeding stage can be distinguished. ——— succeeding stage seven-spined. – – – – succeeding stage five-spined.

The length frequency distributions of the mandibular palp, 1st thoracic appendage and inner antennular flagellum, are stated below in Table XVIII and shown

Table XVI. *Analysis of larvae with seven terminal spines on the telson from St.* 374

Length mm.	Rostral spine	Length of antennular flagellum		Mandibular palp			1st thoracic leg			Telson		Remarks
		mm.	Micro units	Form	mm.	Micro units	Form	mm.	Micro units	Form	No. of spines in succeeding stage	
5·25	0	0·23	5·5	*b–c*	0·42	10	*c*	2·71	65	*a*	7	
5·30	0	0·23	5·5	*b–c*	0·44	10·5	*b*	2·63	63	*b*	7	
5·30	0	0·21	5·0	*b*	0·44	10·5	*b–c*	2·75	66	*a–b*	7	
5·42	0	0·25	6	*a*	0·38	9	*b*	2·46	59	*b*	7	
5·50	0	0·21	5	*b*	0·54	13	*a*	2·63	63	*a, b, c*	7	
5·79	0	0·25	6	*c*	0·75	18	*d*	2·92	70	*b–c*	7	
5·83	0	0·25	6	*b*	0·46	11	*c*	2·42	58	*b–c*	7	Note 1
5·83	0	0·48	11·5	*g–h*	1·08	26	*g*	3·79	91	*g*	7 ?	
5·92	+	0·29	7	*e–f*	0·83	20	*d*	3·38	81	*c*	7 ?	
6·00	0	0·29	7	*c*	0·58	14	*d*	2·96	71	*b–c*	7	
6·13	0	0·29	7	*c*	0·67	16	*e*	3·75	90	*e*	7 ?	Note 2
6·25	+	0·29	7	*f*	0·92	22	*f–g*	3·58	86	*e*	7 ?	
6·25	0	0·31	7·5	*f*	1·08	26	*e–f*	3·33	80	*b–c*	7	
6·38	0	0·38	9	*f*	1·04	25	*e*	3·63	87	*d–e*	7 ?	
6·42	+	0·50	12	*h*	1·04	25	*h*	3·96	95	*f*	5 ?	
6·42	0	0·42	10	*h*	1·21	29	*g*	3·88	93	*f*	5	
6·46	+	0·38	9	*e–f*	0·83	20	*e–f*	3·88	93	*f*	5	
6·46	+	0·38	9	*g*	1·04	25	*g–h*	3·92	94	*f–g*	7 ?	
6·50	0	0·38	9	*d–e*	0·71	17	*e*	3·50	84	*e*	5 ?	
6·50	0	0·42	10	*f*	1·04	25	*f–g*	3·67	88	*f*	5	
6·54	0	0·38	9	*f–g*	0·96	23	*g*	3·96	95	*e–f*	7 ?	
6·54	+	0·42	10	*f*	1·04	25	*f*	4·17	100	*e–f*	5	
6·54	+	0·42	10	*g–h*	1·17	28	*g*	3·92	94	*g*	5	
6·54	+	0·42	10	*g–h*	1·17	28	*g–h*	4·08	98	*h*	5 ?	
6·58	0	0·38	9	*g*	1·11	26·5	—	—	—	*g–h*	7 ?	
6·58	0	0·40	9·5	*g*	1·17	28	*f–g*	3·96	95	*d–e*	7 ?	
6·63	+	0·38	9	*h*	0·83	20	*f–g*	3·54	85	*g*	7 ?	
6·63	0	0·33	8	*g–h*	1·13	27	*h*	3·71	89	*f*	7 ?	
6·63	0	0·38	9	*g–h*	1·17	28	*h*	4·08	98	*f*	7 ?	
6·63	0	0·44	10·5	*h–j*	1·29	31	*g*	3·96	95	*g*	5	
6·67	0	0·42	10	*f*	1·00	24	*f*	3·96	95	*f–g*	7 ?	
6·67	+	0·38	9	*f*	1·25	30	*g*	4·04	97	*f*	5	
6·71	0	0·42	10	*e–f*	0·96	23	*f*	4·08	98	*e–f*	5	
6·71	0	0·44	10·5	*g–h*	1·00	24	*g–h*	4·17	100	*g–h*	7 ?	
6·75	0	0·42	10	*f–g*	0·96	23	*g*	3·88	93	*f–g*	5	
6·75	+	0·42	10	*g*	1·04	25	*g*	4·38	105	*g–h*	7 ?	
6·75	+	0·46	11	*h*	1·13	27	*h*	—	—	*g–h*	5	
6·75	+	0·46	11	*f–g*	1·21	29	*f–g*	4·00	96	*f*	5	
6·79	0	0·46	11	*j*	1·13	27	*j*	4·13	99	*j*	7 ?	
6·83	+	0·42	10	*g–h*	1·21	29	—	—	—	*h*	5	
6·88	+	0·40	9·5	*g*	1·08	26	*g*	3·79	91	*f*	5	
6·88	0	0·42	10	*h*	1·21	29	*g–h*	4·25	102	*g–h*	7 ?	
6·88	+	0·50	12	*j*	1·46	35	*h*	4·21	101	*j*	5	
6·92	0	0·42	10	*h*	1·17	28	*g–h*	4·08	98	*g–h*	7 ?	
6·96	0	0·46	11	*h*	1·17	28	*h*	3·92	94	*h*	7 ?	
7·00	0	0·44	10·5	*g–h*	1·21	29	*g*	4·17	100	*h*	5	
7·00	+	0·48	11·5	*g–h*	1·25	30	*g–h*	3·92	94	*h*	5	

Table XVI (*cont.*)

Length mm.	Rostral spine	Length of antennular flagellum		Mandibular palp			1st thoracic leg			Telson		Remarks
		mm.	Micro units	Form	mm.	Micro units	Form	mm.	Micro units	Form	No. of spines in succeeding stage	
7·00	+	0·46	11	*j*	1·25	30	—	—	—	*j*	5	
7·00	+	0·48	11·5	*j*	1·25	30	*h*	4·29	103	*h–j*	5	
7·00	+	0·44	10·5	*h–j*	1·29	31	*h–j*	4·29	103	*h–j*	5	
7·04	+	—	—	*j*	1·33	32	—	—	—	*h–j*	5	
7·08	+	0·46	11	*f–g*	1·08	26	*g–h*	3·88	93	*h*	5	
7·08	+	0·46	11	*j*	1·46	35	*h–j*	4·75	114	*h–j*	5	
7·13	+	0·42	10	*g*	1·04	25	*g–h*	3·88	93	*g–h*	5	
7·13	+	0·48	11·5	*j*	1·21	29	*j*	4·04	97	*j*	5	
7·13	+	0·50	12	*h–j*	1·25	30	*j*	4·42	106	*j*	5	
7·13	+	0·54	13	*j*	1·33	32	*j*	4·46	107	*h–j*	5	
7·16	+	0·52	12·5	*j*	1·33	32	*j*	4·38	105	*j*	5	
7·25	0	0·42	10	*h*	1·21	29	*h*	4·33	104	*h*	5	
7·38	+	0·50	12	*j*	1·54	37	*j*	4·42	106	*j*	5	
7·41	+	0·52	12·5	*j*	1·38	33	*j*	4·71	113	*j*	5	

See footnote to Table XIV (p. 44) for explanation of the letters denoting the form of the mandibular palp, 1st thoracic leg and telson.

Note 1. The left 5th pleopod is non-setose, the right is setose.

Note 2. The mandibular palp is unsegmented. The endopod of the 1st thoracic leg is five-segmented.

Table XVII

Length classes mm.	Total no. of larvae	Following stage		
		7-spined	5-spined	Uncertain
5·25–5·49	4	4	—	—
5·50–5·74	1	1	—	—
5·75–5·99	4	2	—	2
6·00–6·24	2	1	—	1
6·25–6·49	7	1	2	4
6·50–6·74	16	—	6	10
6·75–6·99	11	—	6	5
7·00–7·24	13	—	13	—
7·25–7·49	3	—	3	—
Total	61	9	30	22

graphically in Fig. 10. The graphs for the length frequencies of these appendages are bimodal, a less conspicuous maximum representing the smaller number of larvae of small size in this sample and a more conspicuous one for the bulk of the sample which is made up of large average size.

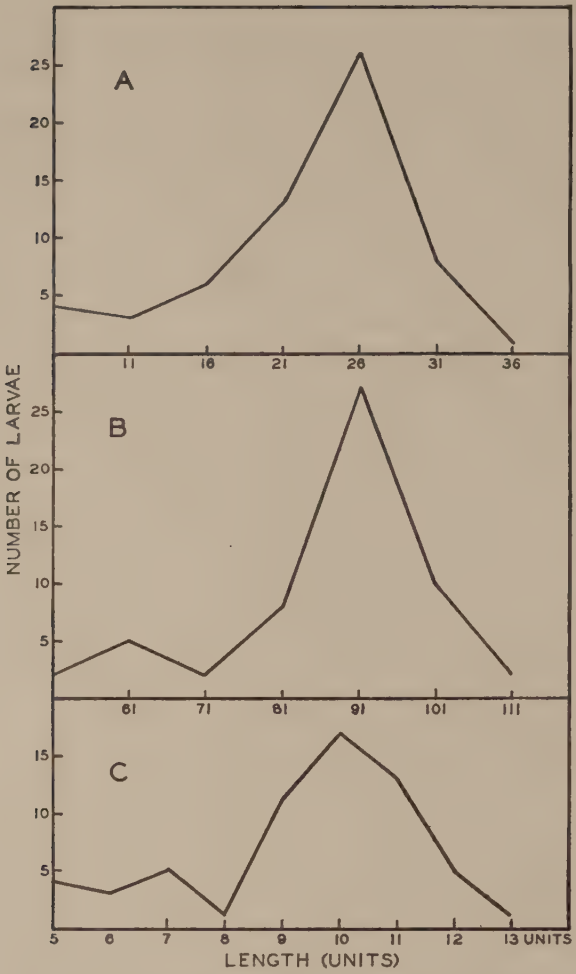

Fig. 10. Length frequencies of: *A*, mandibular palp; *B*, first thoracic appendage; *C*, antennular flagellum.

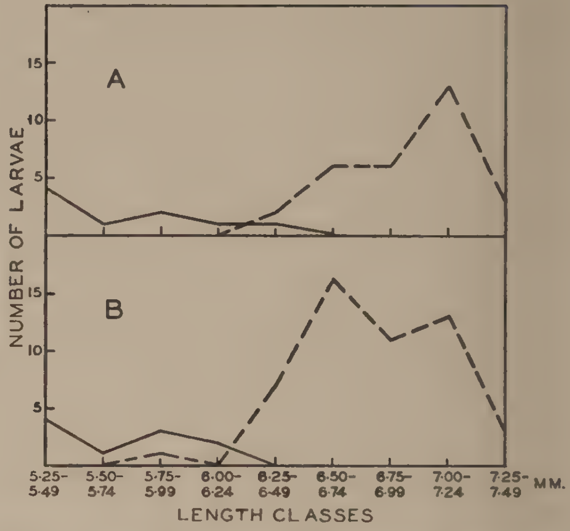

Fig. 11. Length frequencies of larvae with seven-spined telson arranged according to their degree of development.

A, seven-spined larvae in which the telson form in the succeeding stage can be distinguished.

——— succeeding stage seven-spined. – – – – succeeding stage five-spined.

B, seven spined larvae arranged with reference to nine selected larvae (see Fig. 8).

——— degree of development *a–d*. – – – – degree of development *e–j*.

Table XVIII. *Length frequencies of mandibular palp, 1st thoracic appendage and antennular flagellum*

Mandibular palp			1st thoracic palp			Antennular flagellum		
Length class		No.	Length class		No.	Length class		No.
Units	mm.		Units	mm.		Units	mm.	
6–11	0·25–0·46	4	50–60	2·08–2·50	2	5–6	0·21–0·25	4
11–16	0·46–0·67	3	60–70	2·50–2·92	5	6–7	0·25–0·29	3
16–21	0·67–0·88	6	70–80	2·92–3·33	2	7–8	0·29–0·33	5
21–26	0·88–1·08	13	80–90	3·33–3·75	8	8–9	0·33–0·38	1
26–31	1·08–1·29	26	90–100	3·75–4·17	27	9–10	0·38–0·42	11
31–36	1·29–1·50	8	100–110	4·17–4·58	10	10–11	0·42–0·46	17
36–41	1·50–1·71	1	110–120	4·58–5·00	2	11–12	0·46–0·50	13
						12–13	0·50–0·54	5
						13–14	0·54–0·58	1

If the larvae are arranged in two groups according to their average development as expressed by their correspondence to the scale provided by the nine larvae mentioned above, the result (Table XIX) is two sets of figures which correspond in their range with those of the larvae which are to be seven-spined or five-spined respectively in the following stage. This is shown graphically in Fig. 11.

Table XIX. *Larvae with seven-spined telson from St.* 374 *arranged in length groups according to their degree of development*

Length classes mm.	Degree of development	
	a–d	*e–j*
5·25–5·49	4	—
5·50–5·74	1	—
5·75–5·99	3	1
6·00–6·24	2	—
6·25–6·49	—	7
6·50–6·74	—	16
6·75–6·99	—	11
7·00–7·24	—	13
7·25–7·49	—	3

Attention is drawn here to Table XV for specimens from St. 639 in which the average size of the larvae is much less than at St. 374. The larvae compare with the group of larvae of small size at St. 374, and with the exception of two they can, like these latter, be included in the range of development *a* to *d*.

From these analyses, therefore, it is possible to reach the conclusion that in the development of *Euphausia superba* the larvae possessing five pairs of setose pleopods and seven terminal spines can be divided into two groups: (*A*) those having a succeeding seven-spined stage and (*B*) those having a succeeding five-spined stage.

The larvae may be identified as follows:

Form A	*Form B*
Smaller average size.	Larger average size.
Antennular flagellum usually shorter than the two distal segments of the antennule.	Antennular flagellum usually longer.
Mandibular palp sausage-shaped, not generally multiarticulate.	Mandibular palp distinctly three-segmented and with terminal spine developed.
Endopod of 1st thoracic limb not developed as a swimming foot, about twice as long as exopod.	Endopod of 1st thoracic limb five-segmented, much more than twice as long as exopod.
Telson not having innermost postero-lateral spine greatly modified.	Telson with proximal portion widened greatly in comparison with the distal portion.
Telson length not fully three times the width.	Telson length more than three times the width.

LATER FURCILIA STAGES

For the development of the larvae after they have the full complement of setose pleopods and less than seven terminal spines on the telson, a random sample of 243 larvae from St. 374 was examined.

The following observations were made:

Total length of larva.
Telson: (*a*) Number of terminal spines.
    (*b*) Number of postero-lateral spines.
Number of spines on the telson foreshadowed for the succeeding stage.
Antenna. Number of segments in inner ramus.
Mandibular palp: (*a*) Number of segments.
    (*b*) Number of spines on the terminal segment.
1st thoracic appendage. Number of segments in the endopod.
Presence or absence of a spine on the rostrum.

In addition to the evidence from these observations, the records of larvae from the 70-cm. net samples generally, and from the oblique and horizontal net samples from the circumpolar cruise have been utilized.

Before proceeding with the discussion of this evidence it is proposed to consider the term "Cyrtopia" applied to euphausian larvae. As stated above (p. 32) the name was applied by Dana to distinguish a schizopodous genus which was afterwards shown by Claus to be a stage in the development of Euphausiidae. Later workers have adopted this division of larval development, and recognize the Cyrtopia by the alteration in form and function of the antenna of earlier stages. Rustad states (1930, pp. 68 *et seq.*): "The Furcilia stages are characterized by having the antennae retained as swimming appendages whereas in the Cyrtopia stages they are directed forwards and evidently have no importance for swimming. In preserved material, however, where the antennae as a rule are directed forwards in late Furcilia stages one must have recourse to morphological characteristics and concerning this Lebour writes (1925, p. 816) 'The best way to distinguish a late Furcilia from an early Cyrtopia is by the flagellum of the antenna which is unjointed in the Furcilia and jointed in the Cyrtopia'."

Considering the indefinite nature of later euphausian development which has already been demonstrated and anticipating the conclusions derived from the sample of larvae from St. 374, it seems that the recognition of the Cyrtopia places too much stress on the alteration of form and function of one particular appendage. The larvae designated Cyrtopia are not recognizable from Furcilia by any sudden increase in size as they change from the old to the altered form. The change in the antenna does not necessarily coincide with equally significant changes in the form of other appendages, for example, the mandibular palp and the 1st thoracic appendage. It varies also in relation to the development of the telson: for the number of terminal telson spines in the first Cyrtopia of various species of euphausians is given as:

Meganyctiphanes norvegica	7	terminal spines.
Thysanoessa raschii		
Euphausia krohnii	5	,,
Nyctiphanes couchii	3	,,
Nematoscelis microps	1	,,
Thysanopoda aequalis		

It is apparent, therefore, that the change in the antenna is not of the significance formerly attributed to it, and the altered form does not merit the distinction of a division in the larval history. It is merely one of several changes in form, and presumably in function, which take place in the larval appendages in the process of development. These changes are probably intimately connected with the provision of other appendages to do the work performed in earlier stages of the life history by those more anteriorly placed.

The name Furcilia will therefore be used here to describe all the later developmental stages in *Euphausia superba*.

The larvae in a sample of 243 individuals from St. 374 have been arranged in Table XX in order of ascending size, and when of the same size roughly according to the degree of development of various appendages.

LENGTH AND TELSON. In Table XXI the larvae have been arranged according to their length frequency. The succession of peaks presented is to some extent made intelligible by distinguishing the larvae according to the number of spines on the telson. There is a correspondence in position of the maxima in the length frequency of all the larvae with those identified according to the telson spine number. Increase in size is accompanied by reduction in the number of telson spines, but there is a great amount of overlapping in the length range of any one telson spine group and the length ranges which succeed and precede it.

The reduction in the number of telson spines is brought about normally by the disappearance of the outermost on either side so that the reduced numbers are 5, 3 and 1. This is not invariable, as the telson spine numbers 6, 4 and 2 indicate in Table XXI; but these forms are present in such small numbers in relation to those with 5, 3 and 1 that they must be regarded as exceptional. Independent evidence in favour of such a conclusion is provided by the frequency, as expressed by the number of stations at which they were found, of larvae having the different forms of telson recognized. Thus:

Larvae with 6 terminal spines occur at 5 stations.
" 5 " " " 20 "
" 4 " " " 4 "
" 3 " " " 11 "
" 2 " " " 2 "
" 1 " " " 32 "

Several aberrant telson forms are referred to in the notes below the list on p. 53, and some of these are figured (Fig. 12). In three of the figures of unusual telson form the number of spines in the succeeding stage is shown—all three indicate that the aberration of telson form persists when the larva moults.

TELSON SPINE NUMBERS. In Table XXII are stated the length frequencies of larvae arranged according to the number of telson spines in the succeeding stage. Here again, in the seven-spined larvae as in earlier analyses, the smaller ones tend to moult again into seven-spined forms and the larger into five-spined forms. In the five-spined larvae similarly a few moult again into five-spined forms, and there is a surprisingly large number with four spines, but the greater number moult directly into a three-spined form.

In the three-spined larvae it is more difficult to distinguish the number of spines to be found in the succeeding stage, but in those in which it is possible, a succeeding one-spined stage predominates. One larva has two spines in the following stage and there is no sign that any are to be three-spined.

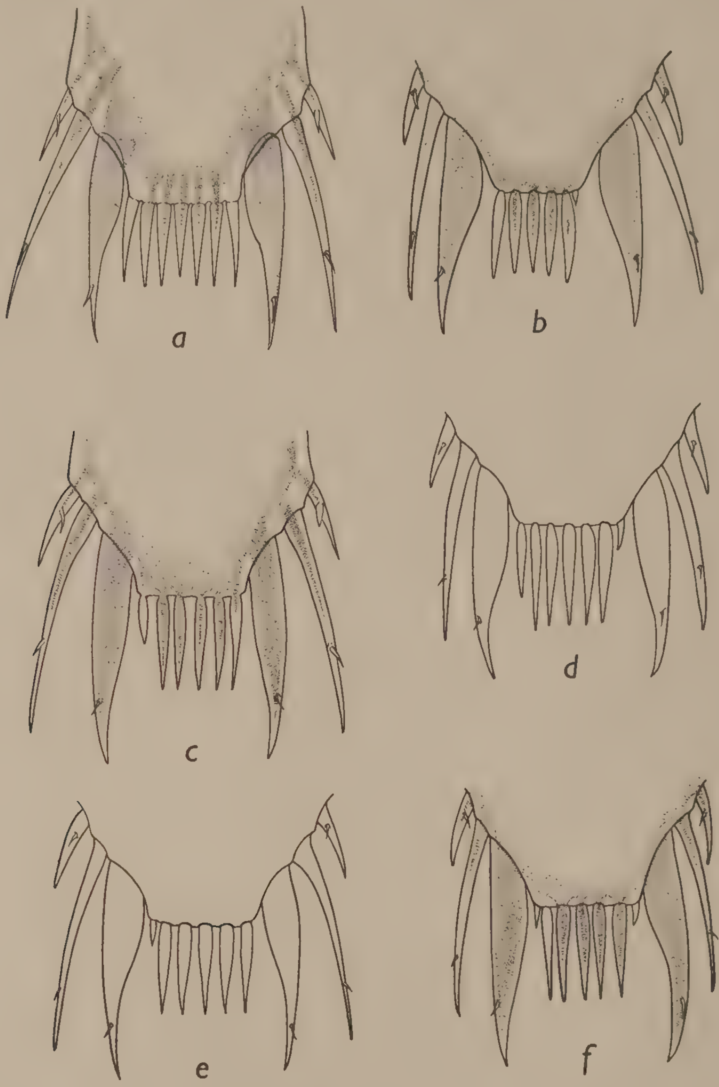

Fig. 12. Normal and abnormal types of telson tip in Furcilia stages (× 85).
a, the normal seven-spined telson. *b–e*, abnormalities.

In Table XX, *b* is referred to under Note 10, *c* under Note 12, *d* under Note 13, *e* under Note 14, *f* under Note 15. In *a*, *b*, *c* and *f*, the form of the telson in the succeeding stage can be distinguished.

It would appear therefore that in the succession of moults which follow on the larvae having five setose pairs of pleopods and the *B* form of telson, the ecdyses generally coincide with a reduction in the number of terminal spines in the telson from seven to

Table XX. *Characters of late Furcilia larvae from St.* 374

Total length mm.	Telson spines		Rostral spine	Terminal spines of telson in following stage	Segments of inner ramus of antenna	Mandibular palp		Segments of 1st thoracic limb	Remarks
	Terminal	Postero-lateral				Segments	Spines on terminal segment		
5·00	7	3 *A*	...	7	1	Rud.	...	2	Pleopods V non-setose
5·29	7	3 *A*	0	...	1	Rud.	...	3 or 4	
5·42	7	3 *A*	0	7	1	Rud.	...	2	Pleopods V non-setose
5·54	7	3 *A*	...	7	1	3	1	2	Pleopods V non-setose. Note 1
5·63	7	3 *A*	0	7	1	1	0	2	Pleopods just setose. Note 2
5·67	7	3 *A*	0	7	1	3	0	3 or 4	
5·71	7	3 *A*	0	7	1	3	0	3	Note 3
5·75	7	3 *A*	...	7	1	3	0	3	
5·75	7	3 *A*	0	7?	1	3	Rud.	3	Note 4
5·82	7	3 *A*	0	7	1	1	0	2	
6·00	7	3 *A*	+	...	1	3	1	Missing	
6·04	7	3 *A*	0	7	1	1	0	3	
6·04	7	3 *A*	...	7	1	2	0	3–4	
6·04	7	3 *A*	...	7	1	2?	0	5	Pleopods V non-setose
6·08	7	3 *A*	0	7	1	1	0	3?	
6·21	7	3 *A–B*	0	7?	1	3	1	5	
6·29	7	3 *B*	+	...	1	3	1	5	
6·42	7	3 *A–B*	+	7?	1	3	1	5	
6·42	7	3 *A–B*	0	...	1	3	1	5	
6·42	7	3 *A*	...	...	1	3	1	5	
6·46	7	3 *B*	+	5	1	3	1	5	
6·50	7	3 *B*	0	5	1	3	1	5	
6·58	7	3 *A–B*	0	6	1	Rud.	...	4 or 5	Note 5
6·58	7	3 *B*?	0	...	1	3	1	5	
6·58	7	3 *A–B*	0	7?	1	3	1	5	
6·67	7	3	0	...	1	3	1	5	
6·67	7	3 *B*	0	...	1	3	1	5	
6·67	7	3 *B*	+	5?	1	3	1	5	

Note 1. The mandibular palp is definitely three-segmented with a short terminal spine on the distal segment.

Note 2. The first thoracic appendage is of the primitive form with two-segmented endopod. The distal segment is indistinctly divided into three within the integument.

Note 3. The larva is very near ecdysis, so that the mandibular palp appears six-segmented—the three existing segments and the three of the following stage. The existing cuticle was dissected from the telson leaving the seven terminal spines of the following stage.

Note 4. The one mandibular palp consists of three segments with a very small spine at the tip of the distal one; the palp as a whole is small and sausage-shaped. The other palp is indistinctly three-segmented with no spine at the end.

Note 5. The antennular flagella are only slightly longer than the distal peduncular segment. The mandibular palp is sausage-shaped. The inner ramus of the first thoracic appendage is little more than twice the length of the exopod: it is impossible to state certainly whether it is composed of four or five segments.

Table XX (*cont.*)

Total length mm.	Telson spines		Rostral spine	Terminal spines of telson in following stage	Segments of inner ramus of antenna	Mandibular palp		Segments of 1st thoracic limb	Remarks
	Terminal	Postero-lateral				Segments	Spines on terminal segment		
6·67	7	3 *B*	0	5	1	3	1	5	
6·71	6	3	+	...	1	3	1	5	Note 6
6·71	7	3 *B*	0	6	1	3	1	5	
6·71	7	3	...	5	1	3	1	5	
6·75	7	3 *B*	+	5	1	3	1	5	
6·75	7	3	0	7	1	3	1	5	
6·75	7	3 *B*	+	5	1	3	1	5	
6·75	7	3 *B*	0	5	1	3	1	5	
6·79	5	3	...	4	1	3	1	5	
6·83	7	3 *B*	+	...	1	3	1	5	
6·83	7	3 *B*	0	5	1	3	1	5	
6·83	7	3 *B*	0	5	1	3	1	5	
6·83	7	3 *B*	0	5	1	3	1	5	
6·83	7	3 *B*	0	5	1	3	1	5	
6·88	7	3	...	...	1	3	1	5	
6·88	5	3	0	...	1	3	1	5	
6·88	7	3 *B*	0	...	1	3	1	5	
6·88	7	3 *B*	+	5	1	3	1	5	
6·88	7	3 *B*	0	5	1	3	1	5	
6·88	7	3 *B*	+	6	1	3	1	5	
6·88	7	3 *B*	+	5	1	3	1	5	
6·88	7	3 *B*	0	5	1	3	1	5	
6·92	5	3	0	...	1	3	1	5	
6·92	5	3	+	...	1	3	1	5	
6·92	7	3 *B*	...	...	1	3	1	5	
6·92	7	3 *B*	+	7 ?	1	3	1	5	
6·96	7	3 *B*	0	7 ?	1	3	1	5	
6·96	7	3 *A–B*	0	5	1	3	1	5	
6·96	7	3 *B*	0	5	1	3	1	5	
6·96	7	3 *B*	0	5	1	3	1	5	
6·96	6	3	0	5	1	3	1	5	Note 7
7·00	5	3	0	...	1	3	1	5	
7·00	7	3 *B*	0	...	1	3	1	5	
7·00	7	3 *B*	0	5	1	3	1	5	
7·00	7	3 *B*	0	5	1	3	1	5	
7·00	7	3 *B*	...	5	1	3	1	5	
7·00	6	3 *B*	+	...	1	3	1	5	
7·00	5	3	...	3 ?	1	3	1	5	
7·04	7	3 *B*	0	5	1	3	1	5	
7·04	5	3	...	5	1	3	1	5	
7·08	7	3	0	5 ?	1	3	1	5	

Note 6. The five normal terminal spines of the telson are subequal in length; on the extreme left is a small spine less than half the length of the others. There are clearly defined projections into the five larger spines indicating that the succeeding stage will be five-spined.

Note 7. There will be five telson spines in the succeeding stage, there is no projection into the existing spine on the right.

Table XX (*cont.*)

Total length mm.	Telson spines		Rostral spine	Terminal spines of telson in following stage	Segments of inner ramus of antenna	Mandibular palp		Segments of 1st thoracic limb	Remarks
	Terminal	Postero-lateral				Segments	Spines on terminal segment		
7·08	7	3 *B*	+	5	1	3	1	5 ?	1st thoracic limb broken
7·08	7	3	...	5	1	3	1	5	
7·08	6	3 *B*	0	5	1	3	1	5	Note 8
7·08	5	3	...	...	1	3	1	5	
7·08	5	3	0	5 ?	1	3	1	5	
7·08	5	3	+	3	1	3	1	5	
7·13	6	3	+	5	1	3	1	5	Note 9
7·13	5	3	+	4	1	3	1	5	Note 10
7·17	7	3 *B*	...	5	1	3	1	5	
7·17	5	3	...	5	1	3	1	5	
7·17	5	3	+	4	1	3	1	5	
7·17	5	3	+	3	1	3	1	5	
7·21	7	3 *B*	+	5	1	3	1	5	
7·21	5	3	+	5	1	3	1	5	
7·21	5	3	+	5 ?	1	3	1	5	
7·21	5	3	0	3	1	3	1	5	
7·21	5	3	+	3	1	3	1	5	
7·21	5	3	0	3	1	3	1	5	
7·25	7	3 *B*	+	5	1	3	1	5	
7·25	5	3	0	5 ?	1	3	1	5	
7·29	7	3 *B*	...	5	1	3	1	5	
7·29	7	3 *B*	+	5	1	3	1	5	
7·29	6	3	0	5	1	3	1	5	Note 11
7·29	5	3	+	5	1	3	1	5	
7·29	5	3	0	4	1	3	1	5	
7·29	5	3	+	3	1	3	1	5	
7·33	5	3	0	5	1	3	1	5	
7·33	6	3 *B*	...	4+	1	3	1	5	Note 12
7·38	7	3 *B*	0	5	1	3	1	5	Note 13

Note 8. Telson with six terminal spines, but there will be five terminal spines in the following stage. There is no projection into the existing spine on the extreme left.

Note 9. As in Note 6.

Note 10. On the telson the outermost terminal spine on the right is a very small vestige, about one-tenth the length of the spine next to it. Within the integument there are four projections into the spines; there is no projection into the small spine on the right nor into the outermost on the left (see Fig. 12 *b*).

Note 11. As in Note 6.

Note 12. Of the six terminal spines on the telson the outermost on the left is half the length of that next to it. The number of spines in the following stage is four large normal spines and a very small fifth one on the extreme right. The latter may atrophy altogether, so that only four spines may be present in the succeeding stage (see Fig. 12 *c*).

Note 13. Of the seven terminal telson spines, the outermost on the right is one-fifth the length of the next to it, the outermost on the left is about three-quarters the length of that next to it. The remaining spines are subequal with a slight reduction in the size from the outermost to the central (see Fig. 12 *d*).

Table XX (*cont.*)

Total length mm.	Telson spines		Rostral spine	Terminal spines of telson in following stage	Segments of inner ramus of antenna	Mandibular palp		Segments of 1st thoracic limb	Remarks
	Terminal	Postero-lateral				Segments	Spines on terminal segment		
7·38	7	3 *B*	+	5	1	3	1	5	
7·38	6	3 *B*	+	5 ?	1	3	1	5	
7·38	6	3	...	5 ?	1	3	1	5	Note 14
7·38	5	3	+	5	1	3	1	5	
7·38	5	3	0	...	1	3	1	5	
7·38	5	3	0	3	...	3	1	5	
7·42	5	3	+	5	1	3	1	5	
7·42	5	3	+	5 ?	1	3	1	5	
7·42	5	3	+	3 ?	1	3	1	5	
7·42	5	3	+	3	1	3	1	5	
7·42	5	3	0	3	...	3	1	5	
7·42	5	3	...	3	...	3	2	5	
7·46	5	3	0	5	1	3	1	5	
7·46	5	3	+	4 ?	1	3	1	5	
7·46	5	3	0	3 ?	1	3	1	5	
7·46	5	3	0	3	1	3	1	5	
7·50	7	3 *B*	...	5	1	3	1	5	
7·50	5	3	0	4	1	3	1	5	
7·50	5	3	+	...	1	3	1	5	
7·50	5	3	0	3	1	3	1	5	
7·50	5	3	...	3	1	3	2	5	
7·54	7	3 *B*	+	5	1	3	1	5	
7·54	7	3 *B*	0	5	1	3	1	5	
7·54	5	3	0	3	1	3	1	5	
7·58	7 ?	3 *B*	0	4	1	3	1	5	Note 15
7·58	6	3 *B*	+	5	1	3	1	5	Note 16
7·58	5	3	+	4 ?	1	3	1	5	
7·58	5	3	0	5 ?	1	3	1	5	
7·58	5	3	0	3	1	3	1	5	
7·58	5	3	0	3	1	3	1	5	
7·58	5	3	...	3	1	3	1	5	
7·58	5	3	+	3	1	3	1	5	
7·58	5	3	0	3	1	3	1	5	
7·58	7	3	0	5	1	3	R2, L1	5	
7·63	7	3 *B*	0	5	1	3	1	5	Note 17
7·63	7	3 *B*	...	5	1	3	1	5	

Note 14. Of the six terminal telson spines the outermost on the left is very small, about one-quarter to one-fifth the length of the next spine to it (see Fig. 12 *e*).

Note 15. Of the seven terminal telson spines, the outermost are only about one-sixth the length of the remainder. There are four projections into the existing spine, there being no projection into either of the small spines nor into the large spine on the left (see Fig. 12 *f*).

Note 16. There are six terminal spines on the telson and there will be five in the following stage; there is no projection into the spine on the extreme right, so that in the existing stage it is the outermost spine on the left which is assumed to be missing.

Note 17. There are seven terminal telson spines; the outermost on each side only about three quarters the length of the remaining five, which are subequal.

Table XX (*cont.*)

Total length mm.	Telson spines		Rostral spine	Terminal spines of telson in following stage	Segments of inner ramus of antenna	Mandibular palp		Segments of 1st thoracic limb	Remarks
	Terminal	Postero-lateral				Segments	Spines on terminal segment		
7·63	6	3 *B*	o	5	1	3	1	5	Note 18
7·63	5	3	...	3	1	3	1	5	
7·67	5	3	+	4	1	3	1	5	Note 19
7·67	5	3	+	...	1	3	1	5	
7·67	5	3	+	3	1	3	1	5	
7·67	5	3	...	3	1	3	R1, L2	5	
7·71	7	3 *B*	+	5	1	3	1	5	
7·71	5	3	+	3	1	3	1	5	
7·79	7	3 *B*	o	5	1	3	1	5	
7·79	5	3	+	4	1	3	1	5	
7·79	5	3	+	3	1	3	1	5	
7·79	5	3	...	3	...	3	1	5	
7·79	5	3	o	3	1	3	1	5	
7·79	5	3	+	3	1	3	R1, L2	5	
7·83	5	3	o	3	1	3	1	5	
7·83	5	3	+	3	1	3	1	5	
7·88	5	3	...	3	...	3	R2, L1	5	
7·92	5	3	+	4	1	3	2	5	
7·92	5	3	o	3	1	3	2	5	
7·96	5	3	+	3	Prob. 1	3	2	5	
8·00	5	3	o	3	1	3	2, 1	5	
8·00	5	3	...	3	1	3	2	5	
8·04	5	3	...	4	2 + 1	3	1	5	
8·13	5	3	...	3	1 + 1	3	2	5	
8·17	5	3	...	3	1	3	2	5	
8·21	5	3	...	3	1	3	2	5	
8·25	5	3	...	3 ?	...	3	1	5	
8·25	5	3	+	3	1	3	1	5	
8·29	5	3	+	3	1	3	1	5	
8·29	5	3	...	3	...	3	2	5	
8·33	5	3	+	3	1	3	2	5	
8·38	5	3	...	3	1 + 1	3	L1, R2	5	Note 20
8·38	3	3	+	...	2 + 1	3	2	5	
8·46	5	3	...	3	...	3	1	5	
8·54	3	3	...	...	1 + 1	3	2	5	
8·58	4	3	+	...	1 + 1	3	2	5	
8·58	3	3	o	...	1	3	2	5	

Note 18. There are six terminal telson spines and there will be five in the next stage. There is no projection into the spine on the extreme left, so that in the existing stage it is the outermost spine on the right which is probably wanting (cf. Note 16 *supra*).

Note 19. Within the integument of the telson four quite well-defined spines are visible. There is no spine projection into the existing spine on the extreme left.

Note 20. There is asymmetry in the development of the appendages of this larva. The left mandibular palp has one large seta, the right two setae on the terminal segment. The left antenna is more primitive than the right, the outer ramus is not scale-like and the inner ramus is very indistinctly divided into two, whereas the left antenna has a definite scale and a distinctly two-segmented flagellum.

Table XX (*cont.*)

Total Length mm.	Telson spines		Rostral spine	Terminal spines of telson in following stage	Segments of inner ramus of antenna	Mandibular palp		Segments of 1st thoracic limb	Remarks
	Terminal	Postero-lateral				Segments	Spines on terminal segment		
8·63	5	3	...	3	1	3	2	5	Note 21
8·75	3	3	0	...	1+1	3	2	5	
8·79	5	3	+	...	...	3	2	5	
8·79	3	3	...	2	2+1	3	2	5	
8·88	3	3	...	...	...	3	3	5	
8·88	3	3	...	...	2+1	3	3, 2	5	
8·92	4	3	+	3	1+1	3	2	5	
8·92	3	3	+	...	2+1	3	R3, L2	5	
8·96	5	3	0	3	...	3	1	5	
8·96	5	3	...	...	1+1	3	R1, L2	5	Note 22
8·96	3	3	+	3?	1+1	3	2	5	
8·96	3	3	0	...	...	3	4	5	
9·08	5	3	+	...	...	3	1	5	
9·17	3	3	+	1?	...	3	R3, L2	5	
9·21	3	3	+	...	2+1	3	3	5	
9·25	3	3	...	...	...	3	2	5	
9·25	3	3	+	...	2+1	3	3	5	
9·25	3	3	...	...	2+1	3	4, 3	5	
9·33	5	3	...	3?	2+1	3	3	5	
9·38	3	3	0	...	2+2	3	2	5	
9·38	3	3	+	1?	...	3	R3, L2	5	
9·38	3	3	...	1?	...	3	3	5	
9·38	3	3	+	...	2+1	3	3	5	
9·38	2	3	+	1	2+3	3	3	5	
9·38	3	3	+	3?	2+3	3	4	5	
9·46	3	3	+	...	2+1	3	2	5	
9·46	3	3	+	...	2+1	3	3	5	
9·46	3	3	...	...	2+1	3	4, 3	5	
9·54	3	3	...	1	2+3	3	2	5	
9·54	3	3	...	...	1+1	3	3	5	
9·58	3	3	...	1	2+1	3	3	5	
9·58	5	3	...	...	2+3	3	4	5	
9·63	4	3	0	...	2+1	3	2	5	
9·63	3	3	+	...	2+1	3	2	5	
9·63	3	3	0	...	2+3	3	3	5	
9·67	3	3	...	...	2+1	3	3	5	
9·67	3	3	...	...	2+1	3	4	5	
9·71	5	3	+	3?	2+1	3	2	5	Note 23
9·71	3	3	+	1	...	3	R3, L2	5	

Note 21. The inner ramus of the antenna is unsegmented, but within the integument there are definite signs of segmentation indicating that when the animal moults there will be 2+1 segments.

Note 22. The inner ramus of the antenna is distinctly divided into two segments, of which the distal gives indication that it becomes three-segmented later.

Note 23. On the telson the terminal spine on the right is only about half the length of the remaining spines.

Table XX (*cont.*)

Total Length mm.	Telson spines		Rostral spine	Terminal spines of telson in following stage	Segments of inner ramus of antenna	Mandibular palp		Segments of 1st thoracic limb	Remarks
	Terminal	Postero-lateral				Segments	Spines on terminal segment		
9·71	3	3	+	...	2+1	3	3	5	
9·79	3	3	+	...	1+1	3	3	5	
9·79	3	3	+	...	2+1	3	3	5	
9·83	3	3	+	...	2+1	3	2	5	
9·83	3	3	...	...	2+1	3	3	5	
9·83	3	...	...	...	2+3	3	3	5	
9·92	3	3	+	...	...	3	R2, L3	5	
9·92	3	3	+	1	2+1	3	3	5	
10·00	5	3	+	3	2+1	3	3	5	
10·00	3	3	0	1 ?	2+2	3	3	5	
10·00	3	3	0	...	2+3	3	3	5	
10·00	3	3	+	...	2+3	3	3	5	
10·00	3	3	+	...	2+3	3	4	5	
10·00	3	3	+	...	2+3	3	3	5	
10·00	3	3	+	1	2+6 or 7	3	3	5	
10·04	2	3	0	1	2+3	3	3	5	
10·08	3	3	0	...	2+|3	3	3	5	
10·08	3	3	+	...	2+|3	3	3	5	
10·21	3	3	...	...	2+|3	3	4	5	
10·33	3	3	...	...	2+|3	3	4	5	
10·38	3	3	+	1	2+|3	3	3	5	Note 24
10·46	3	3	0	1	2+3	3	4	5	
10·50	3	3	...	1 ?	2+3	3	3	5	
10·54	1	3	+	...	2+3	3	4	5	
10·63	3	3	+	...	2+3	3	3	5	
10·63	3	3	+	1	...	3	3	5	
10·67	3	3	+	1	2+3	3	R3, L2	5	
10·71	3	3	+	1	2+3	3	4	5	
10·79	1	3	+	...	...	...	...	...	
11·21	1	3	+	...	2+7	3	5	5	
11·46	1	3	0	...	2+9 or 10	3	4	5	
11·58	1	3	+	...	...	3	4	5	
11·71	1	3	+	...	2+4+*	3	4	5	* Broken
12·38	1	3	...	...	...	3	4	5	
12·92	1	3	+	...	...	3	6	5	

Note 24. The antennal inner ramus consists of two basal segments and a three-segmented flagellum. Within the integument of the flagellum can be distinguished a much greater number of segments—six or eight in number at least.

five, five to three and three to one, but that, as might be expected in arthropods whose development is so undefined, by no means all the larvae conform to this scheme.

Postero-lateral telson spines. In none of the larvae in this sample is the number of postero-lateral spines reduced from three to two as eventually happens. In the seven-spined larvae the state of development of the innermost postero-lateral is shown in

Table XX by the letters *A* or *B*, these letters corresponding respectively to the forms with narrow and broadened proximal portions. As in the description already given, the form with narrow-based spine is restricted to larvae of smaller size, whereas the broadened form is found in the larger seven-spined larvae. As all later larvae have the broadened form of innermost postero-lateral, the letter *B* has been omitted in descriptions of them.

Table XXI. *Length frequency of larvae from St.* 374 *arranged according to the number of terminal telson spines*

Length classes mm.	Terminal telson spine number							
	Total	7	6	5	5	3	2	1
5·00– 5·24	1	1	—	—	—	—	—	—
5·25– 5·49	2	2	—	—	—	—	—	—
5·50– 5·74	4	4	—	—	—	—	—	—
5·75– 5·99	3	3	—	—	—	—	—	—
6·00– 6·24	6	6	—	—	—	—	—	—
6·25– 6·49	5	5	—	—	—	—	—	—
6·50– 6·74	11	10	1	—	—	—	—	—
6·75– 6·99	27	22	1	4	—	—	—	—
7·00– 7·24	28	10	3	15	—	—	—	—
7·25– 7·49	27	5	4	18	—	—	—	—
7·50– 7·74	28	8	2	18	—	—	—	—
7·75– 7·99	12	1	—	11	—	—	—	—
8·00– 8·24	6	—	—	6	—	—	—	—
8·25– 8·49	8	—	—	7	—	1	—	—
8·50– 8·74	4	—	—	1	1	2	—	—
8·75– 8·99	11	—	—	3	1	7	—	—
9·00– 9·24	3	—	—	1	—	2	—	—
9·25– 9·49	13	—	—	1	—	11	1	—
9·50– 9·74	12	—	—	2	1	9	—	—
9·75– 9·99	7	—	—	—	—	7	—	—
10·00–10·24	11	—	—	1	—	9	1	—
10·25–10·49	3	—	—	—	—	3	—	—
10·50–10·74	6	—	—	—	—	5	—	1
10·75–10·99	1	—	—	—	—	—	—	1
11·00–11·24	1	—	—	—	—	—	—	1
11·25–11·49	1	—	—	—	—	—	—	1
11·50–11·74	2	—	—	—	—	—	—	2
11·75–11·99	—	—	—	—	—	—	—	—
12·00–12·24	—	—	—	—	—	—	—	—
12·25–12·49	1	—	—	—	—	—	—	1
12·50–12·74	—	—	—	—	—	—	—	—
12·75–12·99	1	—	—	—	—	—	—	1
Totals	245	77	11	88	3	56	2	8

ANTENNA. The development of the antenna from its primitive form as a swimming appendage into a specialized scale and flagellum takes place within the range of larvae found at this station. The way in which this is brought about is shown in Fig. 13.

The change of the outer ramus into a flattened scale follows the normal course described in other euphausians.

In the inner ramus the unsegmented condition is seen in Fig. 13 *a*. In Fig. 13 *b* this has become divided into two. In Fig. 13 *c* the ramus is still divided into two, but of these the proximal shows a foreshadowing of the two-segmented peduncle of later stages while the distal segment is still unjointed. From this and from the examination of other larvae at this station it is evident that the proximal segment divides into two, forming the peduncle, before segmentation begins in the distal segment. In Fig. 13 *d* the peduncle is distinctly segmented into two and the flagellar portion into four. Within the integument the state of the flagellum in the following stage can be discerned as having a much greater number of segments.

Table XXII. *Length frequency of larvae from St. 374 arranged according to the number of telson spines in the following stage*

Length classes mm.	Telson with 7 spines				Telson with 5 spines				Telson with 3 spines		
	Following stage				Following stage				Following stage		
	7-spined	6-spined	5-spined	Uncertain	5-spined	4-spined	3-spined	Uncertain	2-spined	1-spined	Uncertain
5·00– 5·24	1	—	—	—	—	—	—	—	—	—	—
5·25– 5·49	1	—	—	1	—	—	—	—	—	—	—
5·50– 5·74	4	—	—	—	—	—	—	—	—	—	—
5·75– 5·99	2	—	—	1	—	—	—	—	—	—	—
6·00– 6·24	3	—	—	3	—	—	—	—	—	—	—
6·25– 6·49	—	—	1	4	—	—	—	—	—	—	—
6·50– 6·74	—	2	3	5	—	—	—	—	—	—	—
6·75– 6·99	1	1	14	6	—	1	—	3	—	—	—
7·00– 7·24	—	—	8	2	2	2	5	6	—	—	—
7·25– 7·49	—	—	5	—	5	1	6	6	—	—	—
7·50– 7·74	—	—	8	—	—	2	12	3	—	—	—
7·75– 7·99	—	—	1	—	—	2	9	—	—	—	—
8·00– 8·24	—	—	—	—	—	1	5	—	—	—	—
8·25– 8·49	—	—	—	—	—	—	6	1	—	—	1
8·50– 8·74	—	—	—	—	—	—	1	—	—	—	2
8·75– 8·99	—	—	—	—	—	—	1	2	1	—	6
9·00– 9·24	—	—	—	—	—	—	—	1	—	—	2
9·25– 9·49	—	—	—	—	—	—	—	1	—	—	11
9·50– 9·74	—	—	—	—	—	—	—	2	—	3	6
9·75– 9·99	—	—	—	—	—	—	—	—	—	1	6
10·00–10·24	—	—	—	—	—	—	1	—	—	1	8
10·25–10·49	—	—	—	—	—	—	—	—	—	2	1
10·50–10·74	—	—	—	—	—	—	—	—	—	3	2

Rustad (1930, p. 72) describes two different forms of development of the inner ramus of the antenna in euphausians. In the one (Fig. 14 *b*) the flagellum and peduncle are already separated in the two-segmented stage—the *E. frigida* type. In the other (Fig. 14 *a*) the peduncle and flagellum part in the three-segmented stage—the *Thysanoessa macrura* type. *Euphausia superba* (Fig. 14 *c*) follows the *E. frigida* type but differs from it in that the peduncle divides again into two before segmentation of the flagellum proceeds, whereas in *E. frigida* division of the peduncle coincides with an increase in the number of flagellar segments.

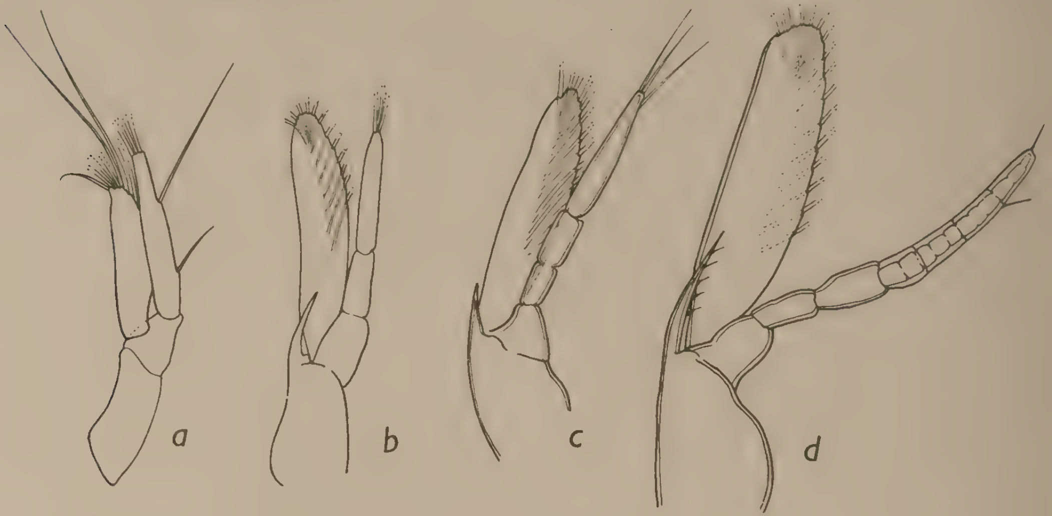

Fig. 13. Development of the antenna (× 46).
a, larva with 5 telson spines; *b*, larva 9·16 mm. long with 3 telson spines; *c*, larva 9·71 mm. long with 3 telson spines; *d*, larva 11·30 mm. long with 3 telson spines.

In the statement of the number of segments in the inner ramus of the antenna of the larvae from St. 374 (Table XX) the number has been expressed as the sum of two, of which the first indicates peduncular and the second flagellar segments.

In Table XXIII the length frequency of the larvae according to the number of terminal spines in the telson and the state of the inner ramus of the antenna are given. None of the seven- or six-spined larvae possess segmented antennal inner rami. Among five-spined larvae 89·7 per cent have unsegmented and 10·3 per cent have segmented antennal inner rami.

The number of four-spined larvae is inconsiderable but all have segmented inner rami. By the time the larvae are three-spined, only a very small minority are unsegmented, and in the two- and one-spined larvae no unsegmented antennae occur. The analysis shows therefore that the change in the form of antenna is not restricted to one stage but may take place in five-spined or three-spined larvae. It also shows that, within

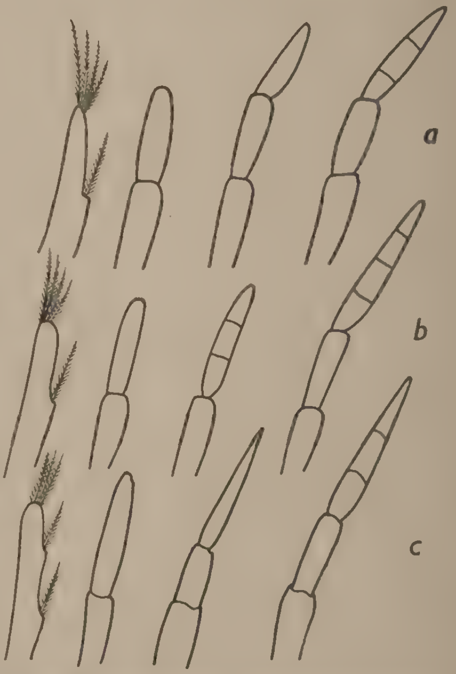

Fig. 14. Segmentation of antennal inner ramus. *a*, *Thysanoessa macrura*; *b*, *Euphausia frigida*; *c*, *E. superba*. Diagrammatic, *a* and *b* after Rustad.

narrow limits at all events, the size does not determine the point at which the antennae should assume the segmented form; for instance, in the five-spined group there is an overlap of 1 mm. in the length distributions of the unsegmented and segmented forms. At the same time, however, it should be noted that of the five-spined larvae which are segmented the length distribution is towards the upper rather than the lower length limit of the five-spined group.

Table XXIII. *Length frequency of Furcilia larvae from St. 374 divided into groups according to the numbers of spines on the telson and the form of the inner ramus of the antenna*

Length classes mm.	Number of telson spines														Total unsegmented	Total segmented
	Seven		Six		Five		Four		Three		Two		One			
	Inner ramus of antenna															
	Unsegmented	Segmented	Unsegmented	Segmented	Unsegmented	Segmented	Unsegmented	Segmented	Unsegmented	Segmented	Unsegmented	Segmented	Unsegmented	Segmented		
5·00– 5·24	1	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—
5·25– 5·49	2	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—
5·50– 5·74	4	—	—	—	—	—	—	—	—	—	—	—	—	—	4	—
5·75– 5·99	3	—	—	—	—	—	—	—	—	—	—	—	—	—	3	—
6·00– 6·24	6	—	—	—	—	—	—	—	—	—	—	—	—	—	6	—
6·25– 6·49	5	—	—	—	—	—	—	—	—	—	—	—	—	—	5	—
6·50– 6·74	10	—	1	—	—	—	—	—	—	—	—	—	—	—	11	—
6·75– 6·99	22	—	1	—	4	—	—	—	—	—	—	—	—	—	27	—
7·00– 7·24	10	—	3	—	15	—	—	—	—	—	—	—	—	—	28	—
7·25– 7·49	5	—	4	—	15	—	—	—	—	—	—	—	—	—	24	—
7·50– 7·74	8	—	2	—	18	—	—	—	—	—	—	—	—	—	28	—
7·75– 7·99	1	—	—	—	8	—	—	—	—	—	—	—	—	—	9	—
8·00– 8·24	—	—	—	—	4	2	—	—	—	—	—	—	—	—	4	2
8·25– 8·49	—	—	—	—	3	1	—	—	—	1	—	—	—	—	3	2
8·50– 8·74	—	—	—	—	1	—	—	1	1	1	—	—	—	—	2	2
8·75– 8·99	—	—	—	—	1	1	—	1	—	5	—	—	—	—	1	7
9·00– 9·24	—	—	—	—	1	—	—	—	—	1	—	—	—	—	1	1
9·25– 9·49	—	—	—	—	—	1	—	—	—	8	—	1	—	—	—	10
9·50– 9·74	—	—	—	—	—	2	—	1	—	8	—	—	—	—	—	11
9·75– 9·99	—	—	—	—	—	—	—	—	—	6	—	—	—	—	—	6
10·00–10·24	—	—	—	—	—	1	—	—	—	9	—	1	—	—	—	11
10·25–10·49	—	—	—	—	—	—	—	—	—	3	—	—	—	—	—	3
10·50–10·74	—	—	—	—	—	—	—	—	—	4	—	—	—	1	—	5
10·75–10·99	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
11·00–11·24	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1
11·25–11·49	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1
11·50–11·74	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1
Percentage	100	—	100	—	89·7	10·3	—	100	2	98	—	100	—	100		

The larvae having segmented antennae show also that the degree of segmentation is *generally* dependent on size. The lengths and number of segments in the antenna of five-spined larvae are given in Table XXIV. With the exception of the first, the larvae show a direct relation between size and number of segments.

Table XXIV. *Larvae with segmented antennae and five terminal spines on the telson*

Length mm.	Number of segments
0·04	2+1
8·13	1+1
8·38	1+1
8·96	1+1
9·33	2+1
9·58	2+1
9·71	2+1
10·00	2+1

There are only three four-spined larvae in which the antennal condition is recorded; of these the two smaller have a two-segmented antenna and the remaining rather larger one three segments.

The relation is most clearly demonstrated in the larvae having three terminal telson spines. In this group there are forty-seven larvae having antennal inner rami varying in development between that which is unsegmented and that in which the inner ramus is composed of two peduncular and more than three flagellar segments. In Table XXV these larvae are set out according to total length and the number of segments in the inner ramus of the antenna. The average length of each group of larvae having the same number of antennal segments is stated. The increase in the number of segments in the antennal endopod varies directly with increase in average length; but as in the size ranges of larvae with unmodified and modified antennae, so here in the number of segments, the size range for any one number of segments overlaps in its lower and upper limits the ranges which precede and succeed it.

Table XXV. *Larvae with three-spined telson. Length frequency and condition of the antennal endopod*

Length classes mm.	Antennal endopod: number of segments					
	1	1+1	2+1	2+2	2+3	2+more than 3
8·25– 8·49	—	—	1	—	—	—
8·50– 8·74	1	1	—	—	—	—
8·75– 8·99	—	2	3	—	—	—
9·00– 9·24	—	—	1	—	—	—
9·25– 9·49	—	—	6	1	1	—
9·50– 9·74	—	1	5	—	2	—
9·75– 9·99	—	1	4	—	1	—
10·00–10·24	—	—	—	1	7	1
10·25–10·49	—	—	—	—	3	—
10·50–10·74	—	—	—	—	4	—
Average length, mm.	8·58	9·12	9·40	9·69	10·13	10·00

In the larvae having a two-spined telson there are only two records of the number of segments in the antennal inner ramus; the number in each is 2 + 3. The one-spined larvae have antennae segmented as follows:

Length	Segmentation of antennal endopod
10·54	2+3
11·21	2+7
11·46	2+9 or 10
11·71	2+4+ (end broken off)

The length distribution of all larvae having segmented antennae, grouped according to the number of segments in the antenna, is given in Table XXVI.

Table XXVI. *Length frequency of Furcilia larvae with segmented antennae arranged according to the number of antennal segments*

Length classes mm.	Number of segments in antenna					Total
	1+1	2+1	2+2	2+3	2+more than 3	
8·00– 8·24	1	1	—	—	—	2
8·25– 8·49	1	1	—	—	—	2
8·50– 8·74	2	—	—	—	—	2
8·75– 8·99	4	3	—	—	—	7
9·00– 9·24	—	1	—	—	—	1
9·25– 9·49	—	7	1	2	—	10
9·50– 9·74	1	7	—	3	—	11
9·75– 9·99	1	4	—	1	—	6
10·00–10·24	—	1	1	8	1	11
10·25–10·49	—	—	—	3	—	3
10·50–10·74	—	—	—	5	—	5
10·75–10·99	—	—	—	—	—	—
11·00–11·24	—	—	—	—	1	1
11·25–11·49	—	—	—	—	1	1
11·50–11·74	—	—	—	—	1	1
Total	10	25	2	22	4	63
Average length, mm.	8·85	8·93	9·69	10·09	11·09	

This arrangement of results shows that, although there is a narrow range of larval length, namely ½ mm., in which it is possible to find any one of the five different forms of segmentation distinguished, the average lengths of the larvae clearly increase with the increasing development of this appendage. Incidentally the relative scarcity of the antennal form 2 + 2 suggests that the normal process of segmentation of the antennal endopod of *Euphausia superba* is as follows: 1, 1 + 1, 2 + 1, 2 + 3.

Mandibular palp. In this appendage the number of segments and the number of spines on the terminal segment were noted.

The change of the mandible from its primitive form takes place entirely within the group of larvae which has seven terminal spines on the telson—all later larvae (and most of the seven-spined larvae) have the three-segmented form of palp.

Inspection of Table XX shows that larvae can occur having the fifth pair of pleopods non-setose but with the mandibular palp in an advanced stage of segmentation (Note 1).

The majority of larvae which are going to moult again into the second form of seven-spined telson larvae have mandibular palps which are primitive in form, but this is not invariable.

The numbers of segments noted in the mandibular palp, and observations of development within the existing integument, indicate that the general process of development is from one to three segments, although occasional larvae have a two-segmented form.

In Table XXVII the length frequency of the larvae and the number of spines in the mandibular palp are stated. In addition each group of larvae distinguished by the number of spines on the mandibular palp has been divided according to the number of terminal spines on the telson. As in the segmentation of the antennal endopod, so in the mandibular palp, increasing length is accompanied by increase in the number of spines on the palp, but the length range of larvae for any particular spine number overlaps in its upper and lower limits the ranges which precede and succeed it.

Larvae with seven terminal spines may have no spines or one or two spines on the mandibular palp, those with five telson spines may have one, two, three or four spines on the palp and so on, so that no mandibular palp spine number or range of numbers is exclusive to larvae having a particular telson spine number. The general development of course is such that the number of spines on the mandibular palp is increased with decrease in the number of spines on the telson, and, as in the segmentation of the antennal endopod, within any one group distinguishable by the number of telson spines, increase in the number of palp spines is directly connected with the average length of larvae.

First thoracic appendage. In the Calyptopis and earlier Furcilia, the 1st thoracic limb is as shown in Fig. 6, having two basal segments, an exopod consisting of a single segment and an endopod of two segments. As already demonstrated with larvae that have five pairs of setose pleopods and still have the unaltered number of seven terminal spines on the telson, the 1st thoracic limb changes from its primitive condition and the endopod assumes its final form by an increase in segmentation from two to five.

Examination of the data obtained from the larvae from St. 374 indicates that this change invariably takes place before the telson becomes five-spined. In the seven-spined larvae the primitive form of the 1st thoracic limb is confined to the smaller larvae which are going to moult again into a seven-spined form.

Rostral spine. The rostrum of each larva was examined to find the frequency of occurrence of the median spine which foreshadows the pointed condition of the adult animal. It is seen that in all forms of larvae distinguished by telson spine number the pointed condition can occur, and that even in larvae having only one terminal spine on the telson it is possible to have the rostral spine undeveloped. The number of larvae which have a rostral spine does, however, increase appreciably as the larvae develop. This is shown in Table XXVIII, where the percentages of the total for each group are

Table XXVII. *Length frequency of larvae with reference to number of spines on telson and mandibular palp*

Mandibular palp spine number	None	1				2					3				4				5	6
Telson spine number	7	7	6	5	Total	7	5	4	3	Total	5	3	2	Total	5	3	1	Total	1	1
Length classes mm.																				
5·00– 5·24	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
5·25– 5·49	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
5·50– 5·74	3	1	—	—	1	—	—	—	—	—	—	—	—		—	—	—		—	—
5·75– 5·99	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
6·00– 6·24	4	2	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
6·25– 6·49	—	5	—	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
6·50– 6·74	1	9	1	—	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
6·75– 6·99	—	22	1	4	27	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
7·00– 7·24	—	10	3	15	28	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
7·25– 7·49	—	5	4	17	26	—	1	—	—	1	—	—	—	—	—	—	—	—	—	—
7·50– 7·74	—	7	2	16	25	1	2	—	—	3	—	—	—	—	—	—	—	—	—	—
7·75– 7·99	—	1	—	6	7	—	5	—	—	5	—	—	—	—	—	—	—	—	—	—
8·00– 8·24	—	—	—	1	1	—	5	—	—	5	—	—	—	—	—	—	—	—	—	—
8·25– 8·49	—	—	—	4	4	—	3	—	1	4	—	—	—	—	—	—	—	—	—	—
8·50– 8·74	—	—	—	—	—	—	1	1	2	4	—	—	—	—	—	—	—	—	—	—
8·75– 8·99	—	—	—	1	1	—	2	1	3	6	—	3	—	3	—	1	—	1	—	—
9·00– 9·24	—	—	—	1	1	—	—	—	—	—	—	2	—	2	—	—	—	—	—	—
9·25– 9·49	—	—	—	—	—	—	—	—	3	3	1	5	1	7	—	3	—	3	—	—
9·50– 9·74	—	—	—	—	—	—	1	1	2	4	—	6	—	6	1	1	—	2	—	—
9·75– 9·99	—	—	—	—	—	—	—	—	1	1	—	6	—	6	—	—	—	—	—	—
10·00–10·24	—	—	—	—	—	—	—	—	—	—	1	7	1	9	—	2	—	2	—	—
10·25–10·49	—	—	—	—	—	—	—	—	—	—	—	1	—	1	—	2	—	2	—	—
10·50–10·74	—	—	—	—	—	—	—	—	—	—	—	4	—	4	—	1	1	2	—	—
10·75–10·99	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
11·00–11·24	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—
11·25–11·49	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—
11·50–11·74	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	2	—	—
11·75–11·99	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
12·00–12·24	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
12·25–12·49	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—
12·50–12·74	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
12·75–12·99	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Total	14	62	11	65	138	1	20	3	12	36	2	34	2	38	1	10	5	16	1	1

also given. The numbers of two- and one-spined larvae are too small to be really indicative of what happens, but from the remaining groups it is clear that the change in form of the rostrum can take place in any one of a number of larval stages, the spinous form tending to be more common in the later than in the earlier stages.

Table XXVIII. *Presence or absence of the rostral spine in late Furcilia larvae*

Number of spines on the telson	Rostral spine			
	Present		Absent	
	Number	%	Number	%
7	21	34	40	66
6	5	55	4	45
5	36	57	27	43
4	2	67	1	33
3	29	76	9	24
2	1	55	1	50
1	4	67	2	33

The examination of these larvae shows that development in *Euphausia superba* in the later Furcilia stages is not a rigidly fixed process in the degree of development of particular appendages in relation to one another. It is only possible to indicate in the most general way the track that development takes.

The analysis also shows what has been referred to at the beginning of this section, namely that in this species the change in form of the antenna is preceded by changes equally fundamental in character in the mandible and the first thoracic appendage. This furnishes a strong argument against the use of the term Cyrtopia for larvae with altered form of the antenna. It may be added that John in his paper on the southern species of *Euphausia*, about to be published, shows that in different species the change in form of the antennae can precede, or accompany the changes in the mandibular palp and 1st thoracic limb.

DESCRIPTION OF FURCILIA STAGES

For the purpose of this description the Furcilia forms are classified in the following stages:

First Furcilia (p. 69). *Pleopods non-setose.* In this stage are included all larvae, in advance of the 3rd Calyptopis, having simple non-setose pleopods.

Second Furcilia (p. 76). *Pleopods setose, postero-lateral and terminal telson spines unaltered.* This stage includes larvae with setose pleopods, up to five pairs in number, having seven terminal spines on the telson and the postero-lateral spines unaltered.

Third Furcilia (p. 84). *All pleopods setose, seven terminal spined telson, postero-lateral spines altered.*

Fourth Furcilia (p. 88). *Five terminal spines on the telson.*

Fifth Furcilia (p. 92). *Three terminal spines on the telson.*

Sixth Furcilia (p. 96). *One terminal spine on the telson, postero-lateral spines not reduced in number.*

This account excludes description of larvae with six-, four-, or two-spined telson; these are rarely occurring aberrant forms which in development are intermediate between those larvae whose telson spine numbers are respectively one greater and one less. Tables giving particulars of these forms are inserted in their appropriate positions.

FIRST FURCILIA

Included in this stage are the following larvae in advance of the 3rd Calyptopis:

(*a*) Larvae with no pleopods.
(*b*) „ 1 pair of non-setose pleopods.
(*c*) „ 2 „ „ „
(*d*) „ 3 „ „ „
(*e*) „ 4 „ „ „
(*f*) „ 5 „ „ „

All these forms, with the exception of (*b*), are represented in the material examined.

In Table XXIX the non-setose larvae have been separated into groups according to the number of pleopods. At the end of each subdivision the number of larvae, their range of size and average length are stated. An examination of the number of larvae recorded in each subdivision demonstrates the dominance of the (*e*) and (*f*) forms, particularly the latter, and the comparative rarity of the others. It will be noted that there is a direct correlation between the number of pleopods and the average sizes in the different groups.

For all the 1st Furcilia the average length is 5·30 mm., and the range is from 3·50 to 6·50 mm.

Larvae having two, three, four and five pairs of non-setose pleopods were examined in detail.

The eyes project beyond the edge of the carapace which has two emarginations anteriorly between which is the rostral plate (Figs. 15 *g*, *h*, *j*). In the two-pleopod form the anterior edges of the rostral plate form a very obtuse angle, but in the larvae with more pleopods the rostrum is evenly rounded, reaching not quite to the distal margin of the basal antennular segment in the smaller larvae and still more distant from it in the larger larvae. The smaller larvae have no spine on the postero-lateral margin of the carapace; it is present, but inconspicuous, in the larva with four pairs of pleopods and is quite a distinct denticle in the largest larva in this group (Figs. 15 *a*, *b*, *c*).

The telson (Figs. 15 *d*, *e*) is seven-spined terminally, has three postero-lateral spines and a spine situated laterally on each side about the middle of the telson length. The seven terminal spines have spinules on each lateral edge; the postero-laterals bear them on the inner edge and less obviously dorsally. Both lateral and postero-lateral spines have a somewhat larger spinule than the rest situated dorsally at some distance from the tip. The telson length is more than twice the width except in the smallest larvae in which it is a little less.

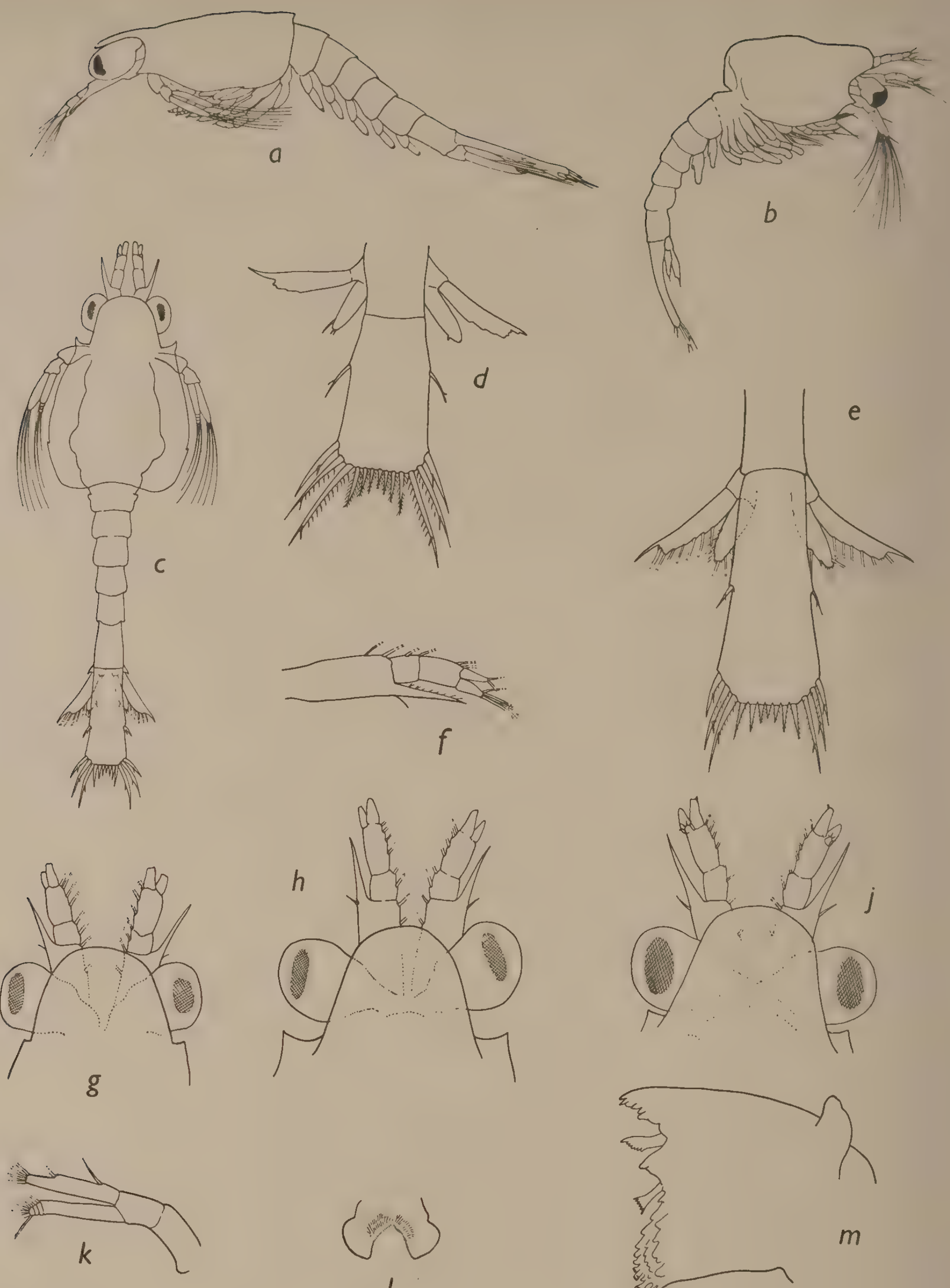

Fig. 15. First Furcilia.

a, lateral aspect of larva with 5 non-setose pleopods (× 14);
b, lateral aspect of larva with 2 non-setose pleopods, carapace distorted (× 14);
c, dorsal aspect of larva with 5 non-setose pleopods (× 14);
d, uropods and telson of larva with 2 non-setose pleopods (× 35);
e, uropods and telson of larva with 5 non-setose pleopods (× 35);
f, antennula of larva with 2 non-setose pleopods (× 35);
g, rostrum and antennule of larva with 3 non-setose pleopods (× 35);
h, rostrum and antennule of larva with 4 non-setose pleopods (× 35);
j, rostrum and antennule of larva with 5 non-setose pleopods (× 35);
k, antenna of larva with 4 non-setose pleopods (× 35);
l, labrum (× 35); *m*, mandible (× 35).

Table XXIX. *Occurrence of First Furcilia*

Station	Date	Depth m.	No. of larvae	No. measured	Length range mm.	Average length mm.
(*a*) **No pleopods**						
WS 527	30. iii. 30	250–100	8	2	3·50	3·50
(*c*) **2 non-setose pleopods**						
WS 527	30. iii. 30	250–100	4	1	3·88	3·88
(*d*) **3 non-setose pleopods**						
321	30. i. 30	100–50	1	1	4·50	4·50
635	7. iii. 31	50–0	2	2	4·08	4·08
636	8. iii. 31	500–250	2	2	4·13–4·25	4·19
854	20. iv. 32	119–0	3	3	4·42–4·63	4·54
WS 527	30. iii. 30	250–100	8	2	3·79–3·83	3·81
			16	10	3·79–4·63	4·23
(*e*) **4 non-setose pleopods**						
171	25. ii. 27	250–100	1	—	—	—
194	25. ii. 27	500–250	2	1	4·88	4·88
197	3. iv. 27	1000–750	2	2	4·75–5·42	5·11
319	29–30. i. 30	1000–750	1	1	4·88	4·88
320	30. i. 30	500–250	5	5	4·46–5·00	4·77
323	31. i. 30	500–250	5	5	4·33–4·83	4·58
324	1. ii. 30	500–250	1	1	4·54	4·54
332	2–3. ii. 30	250–100	1	1	4·92	4·92
358	11. ii. 30	50–0	2	2	4·79–5·00	4·90
361	25. ii. 30	250–100	2	1	4·67	4·67
362	25. ii. 30	250–100	4	4	4·63–4·83	4·72
368	8. iii. 30	100–50	2	2	5·29–5·46	5·36
		250–100	11	11	4·79–5·50	5·06
		500–250	2	2	5·13–5·17	5·15
369	9. iii. 30	50–0	3	3	4·96–5·63	5·36
		250–100	11	11	4·92–5·63	5·35
383	14. iv. 30	100–50	1	1	4·17	4·17
624	21–22. ii. 31	50–0	4	1	5·17	5·17
635	7. iii. 31	50–0	2	2	4·17–4·42	4·30
		100–50	2	2	4·38–4·54	4·46
		250–100	1	1	4·50	4·50
853	19. iv. 32	119–0	2	2	5·25–5·46	5·36
854	20. iv. 32	119–0	1	1	4·92	4·92
855	20. iv. 32	125–0	5	1	4·71	4·71
861	27. iv. 32	109–0	7	7	4·25–4·79	4·72
WS 201	22. iv. 28	50–0	2	2	5·00–5·33	5·17
		100–50	1	1	4·83	4·83
		250–100	1	1	5·17	5·17
WS 202	23. iv. 28	100–50	1	1	4·83	4·83
WS 527	30. iii. 30	250–100	36	9	4·04–4·83	4·37
			121	84	4·04–5·63	4·87

Table XXIX (*cont.*)

Station	Date	Depth m.	No. of larvae	No. measured	Length range mm.	Average length mm.
(*f*) **5 non-setose pleopods**						
169	22. ii. 27	500–250	3	3	5·42–5·79	5·54
193	28. iii. 27	500–250	25	21	5·42–6·17	5·90
		750–500	1	1	5·42	5·42
194	28. iii. 27	100–50	3	3	5·08–5·13	5·10
		250–100	10	9	4·75–5·27	5·01
198	3. iv. 27	50–0	4	4	5·21–5·88	5·53
202	5. iv. 27	50–0	3	3	5·25–5·75	5·54
203	5. iv. 27	100–50	1	1	5·21	5·21
205	6. iv. 27	215–100	1	1	6·00	6·00
303	21. i. 30	500–250	7	7	4·92–5·38	5·09
304	21. i. 30	500–250	4	4	4·96–5·33	5·15
305	21–22. i. 30	100–50	1	1	5·33	5·33
312	24–25. i. 30	220–100	1	1	5·08	5·08
313	25. i. 30	250–100	2	2	5·21–5·42	5·32
319	29–30. i. 30	50–0	10	2	4·58–5·00	4·79
		100–50	1	1	4·83	4·83
		250–100	1	1	4·79	4·79
320	30. i. 30	250–100	4	4	4·96–5·04	5·00
321	30–31. i. 30	100–50	1	1	5·17	5·17
323	31. i. 30	500–250	1	1	5·21	5·21
335	4–5. ii. 30	50–0	1	1	5·08	5·08
342	7. ii. 30	500–250	1	1	5·75	5·75
343	7. ii. 30	250–100	1	1	5·25	5·25
344	7–8. ii. 30	100–50	4	4	5·25–5·54	5·43
356	10. ii. 30	250–100	7	7	5·33–5·92	5·70
360	24. ii. 30	100–50	1	1	5·04	5·04
361	25. ii. 30	50–0	3	3	4·88–5·08	4·99
		100–50	3	3	4·83–5·58	5·25
		250–100	148	50	4·88–5·79	5·26
362	25. ii. 30	50–0	55	50	4·71–5·92	5·22
		250–100	35	35	4·67–5·79	5·05
365	2. iii. 30	50–0	10	10	5·79–6·50	6·09
		100–50	1	1	5·71	5·71
		250–100	129	50	5·33–6·33	5·78
		500–250	2	2	5·63	5·63
368	8. iii. 30	50–0	3	2	5·00–5·67	5·34
		100–50	4	4	5·25–5·38	5·31
		250–100	15	15	5·00–5·83	5·47
369	9. iii. 30	250–100	12	12	5·33–5·92	5·58
383	14. iv. 30	100–50	5	5	4·92–5·13	4·99
		250–100	132	33	5·04–5·71	5·40
635	7. iii. 31	50–0	4	3	4·79–5·00	4·90
855	20. iv. 32	125–0	16	16	5·04–6·04	5·45
		125–0	110	20	5·00–5·75	5·30
861	27. iv. 32	109–0	6	6	4·71–4·96	4·83
		270–138	2	2	4·75–4·88	4·82
WS 197	17. iv. 28	250–100	1	1	5·00	5·00
		500–250	1	1	4·75	4·75
WS 198	19. iv. 28	500–250	5	5	5·17–5·42	5·28
WS 199	20. iv. 28	500–250	31	29	5·04–5·75	5·44
WS 200	21. iv. 28	500–250	79	50	5·42–5·92	5·64
WS 201	22. iv. 28	50–0	6	4	5·42–5·92	5·70
		100–50	1	1	5·63	5·63
		250–100	2	2	5·42–5·50	5·46
WS 202	23. iv. 28	250–100	1	1	5·13	5·13
WS 527	30. iii. 30	250–100	20	5	4·33–4·83	4·55
			951	507	4·33–6·50	5·40

The uropods do not reach to the lateral telson spines even in the largest larvae. They consist of a basal segment and two distal plates which are furnished with long setae; these latter are more numerous in larger than in smaller larvae.

ANTENNULE. The antennules, as in the 3rd Calyptopis, are essentially made up of three peduncular segments and an outer and inner flagellar segment (Figs. 15 *f*, *g*, *h*, *j*). There is an increase in the number of sensory filaments on the outer flagellum in the larger larvae compared with the smaller ones in this group and with the 3rd Calyptopis. There are three filaments, one near the base on the inner margin and two situated terminally. Besides these sensory filaments there are three or four long bristles on each flagellum terminally. In the larger larvae there is also at the distal margin of the distal peduncular segment a rounded protrusion immediately dorsal to the outer flagellum, which is armed with four small curved spines. The number of bristles on the inner margins of the peduncular segments has increased compared with the 3rd Calyptopis. The large spinous forward projection of the basal peduncular segment extends beyond the distal margin of the distal peduncular segment.

ANTENNA, MANDIBLE and LABRUM. These are essentially as in the earlier larval stages (Fig. 15 *k*, *l*, *m*).

FIRST MAXILLA. The general structure is as in the 3rd Calyptopis, but there are certain differences in detail accompanying increase of size. Thus the outer masticatory lobe has seven spines instead of five on the inner margin, and there may be an additional bristle, seen in the larva with five pairs of non-setose pleopods, situated a little distant from the inner margin on the surface of the lobe. The inner masticatory lobe has eight spines compared with seven in the 3rd Calyptopis. The palp of this appendage is more or less distinctly segmented into two, having three spines on the terminal segment and two on the inner margin of the proximal.

SECOND MAXILLA. The 2nd maxillae are as in the 2nd Calyptopis stage with five lateral lobes bearing many setae and a terminal lobe with three setae.

FIRST THORACIC LIMB. The 1st thoracic limb is essentially as in the Calyptopis stages. One is figured for comparison of size with the succeeding limbs (Fig. 16 *d*).

THORACIC LIMBS II–VI. Unlike the 1st limb the remaining thoracic limbs show a distinct advance in development in this stage compared with the 3rd Calyptopis. They have increased greatly in length, so that they are generally as long as, or slightly longer than, the 1st thoracic. In the larvae examined an indication is given of the irregularity in the development of appendages in individual larvae. Thus the larva with only two pairs of pleopods has the thoracic limbs (Fig. 16 *a*) rather more advanced than the larva with three pairs of pleopods (Fig. 16 *b*). This is probably exceptional, and in the normal course one would expect to find the longer and more developed thoracic appendages occurring in larvae with the larger number of pleopods. The segmentation of the endopod is more distinct in larvae with four or five pleopods, so that whereas in the smaller ones the anterior limbs show only the first signs of incipient segmentation and the posterior ones none at all, in the larva with five pleopods (Fig. 16 *d*) the anterior limbs are five-segmented and thoracic limb VI has three segments. The segmentation is difficult to distinguish in preserved material, and up to this point in development it is not possible to make out the articulation of either endopod or exopod with the basal portion of the limb. Another feature which tends to give a confused idea of the number of segments in a limb is that, presumably just prior to moulting, the segmentation of the limb in the following stage is sometimes apparent through the existing integument, and when the joint in the existing integument does not coincide with that of the following stage the

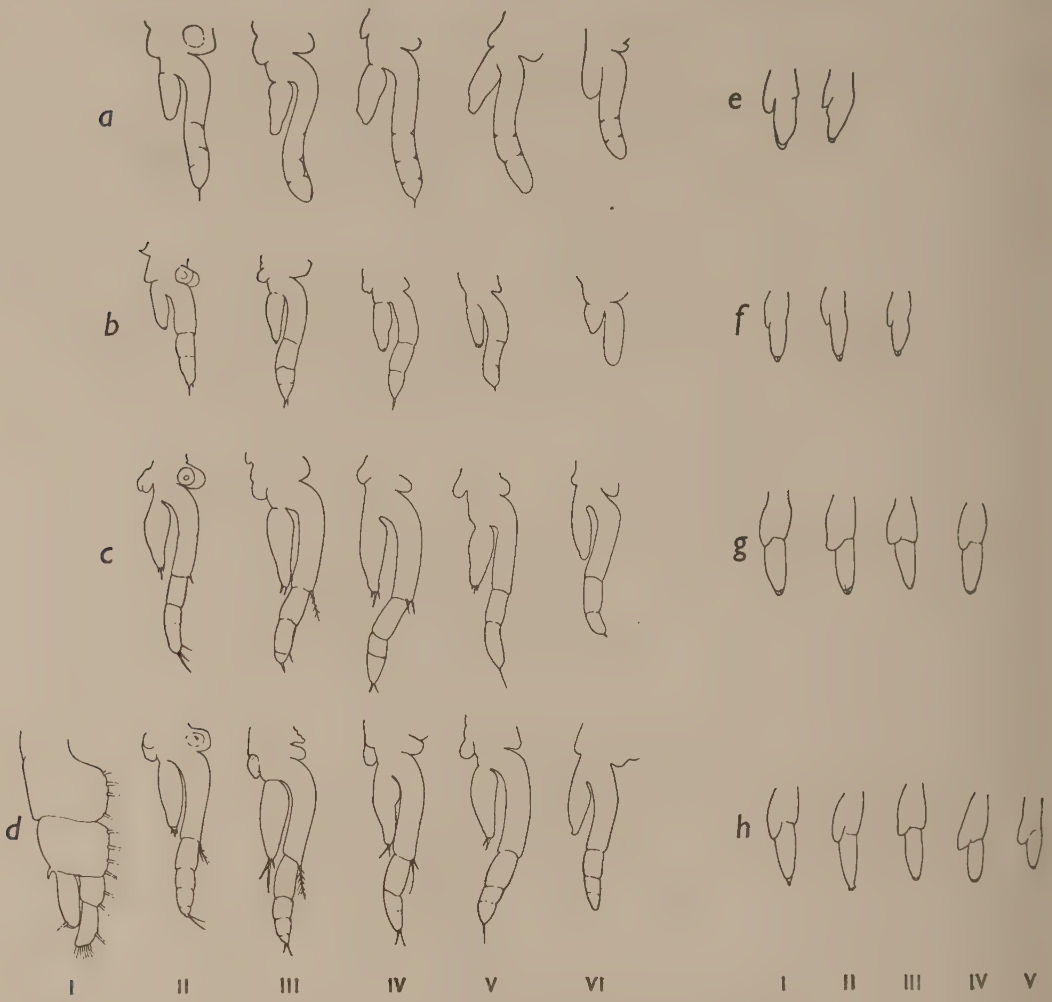

Fig. 16. First Furcilia (continued).

a, thoracic limbs II–VI of larva with 2 non-setose pleopods (×35);
b, thoracic limbs II–VI of larva with 3 non-setose pleopods (×35);
c, thoracic limbs II–VI of larva with 4 non-setose pleopods (×35);
d, thoracic limbs I–VI of larva with 5 non-setose pleopods (×35);
e, pleopods I and II of larva with 2 non-setose pleopods (×35);
f, pleopods I–III of larva with 3 non-setose pleopods (×35);
g, pleopods I–IV of larva with 4 non-setose pleopods (×35);
h, pleopods I–V of larva with 5 non-setose pleopods (×35).

limb has the appearance of having nearly twice as many segments as it actually possesses. The limbs at this stage show a decrease in size and development from in front backwards. There is also an increase in the number of setae in the larvae having the greater number of pleopods, so that instead of two small setae terminally on the endopod of Th. II and III and one seta on Th. IV and V, as in the larvae with three pairs of non-setose pleopods, there are in the larva with five pairs of pleopods on the endopods of Th. II, III and IV two terminal setae and one or two lateral setae and on the endopod of Th. V one terminal seta. The exopods, with the exception of Th. VI, also bear two or three setae at their tips in the larva with five pairs of pleopods. The exopods themselves in the five-pleopod larva show an advance in development from the small larvae in this group, in that they have begun to lose the "sausage shape" and have commenced to show the first signs of the form found in the adult animal.

GILLS. It is in this stage that the gills begin to be obvious on the thoracic limbs. In the larva with three pairs of pleopods they are distinguishable as ill-defined saccular processes on the external margin of the limbs Th. II–V. The gill on Th. VI cannot yet be seen. In the larva with five pairs of pleopods the gills of Th. II, III and IV are slightly bilobed; in Th. V and VI they are simple. Fig. 16 *a–d* shows the gills *in situ*; the bilobed condition is not always obvious when the limb to which the gill is attached is examined dorso-ventrally. There is no sign of a gill on the 1st thoracic appendage of any of the larvae examined.

PLEOPODS. This stage includes, as stated above, larvae having up to five pairs of non-setose pleopods. In the larva having the smallest number, namely two pairs, the limb is distinctly bilobed, having the external lobe or exopod much longer than the internal (Fig. 16*e*). In the first pair of limbs there is already a constriction about the middle of the limb where the exopod merges into the protopodal portion. No such constriction is evident in the endopod nor in either the exopod or endopod of the following pair. In the larva with three pairs of pleopods (Fig. 16*f*) all three pairs are similar to the first pair in the previous larva. There is, however, a decrease in size from in front backwards. In the larvae with four and five pairs of pleopods (Fig. 16*g*, *h*) the constriction separating exopod from protopodite is well defined and clearly segmented. The endopod still merges into the protopodite.

Within the integument of these non-setose pleopods there can be distinguished developing setae, and in some the tip of the pleopod is drawn out into small digitiform processes. The importance of the setae within the integument is discussed in another section (p. 38). Occasionally larvae are found in which the pleopods of the last pair are very dissimilar to those that precede them. They are much smaller pear-shaped buds without any constriction at the middle. This form of limb does not show the rudiments of setae within the integument. Infrequently also larvae are found in which, in the last pair of pleopods, the one is more developed than the other.

LUMINOUS ORGANS. The luminous organ on the ocular peduncle is distinguishable as a fascicle of fibres situated ventrally behind the visual part of the eye. The organ at the base of the limb Th. II is present; that of Th. VII is not yet apparent, nor are any of the unpaired abdominal ones to be seen.

SECOND FURCILIA

Included in this group are the following larvae in advance of the Furcilia stage just described:

(*a*)	With 3 pairs of pleopods:	2 setose, 1 non-setose.
(*b*)	„ 4 „ „	1 „ 3 „
(*c*)	„ 4 „ „	2 „ 2 „
(*d*)	„ 4 „ „	3 „ 1 „
(*e*)	„ 4 „ „	all setose.
(*f*)	„ 5 „ „	2 setose, 3 non-setose.
(*g*)	„ 5 „ „	3 „ 2 „
(*h*)	„ 5 „ „	4 „ 1 „
(*j*)	„ 5 „ „	all setose and having the spines of the telson unaltered.

The above combinations of setose and non-setose pleopods actually occur in the samples examined. It is possible, however, that other variations may be found, for instance, five pleopods of which one pair is setose and four pairs non-setose.

In Table XXX the frequency of occurrence of these larvae with respect to the number of stations and the number of individuals is given. The average lengths are stated in the same manner as in the previous Furcilia stage. For the 2nd Furcilia the average length is 6·11 mm. and the range between 3·96 and 7·92 mm.

The description of this stage is based chiefly on detailed examination of larvae of the forms (*f*), (*g*), (*h*) and (*j*) in the list given above. The larva having the (*f*) form of pleopod development was of small size with the fifth pair of legs not nearly so advanced as in the larva having five pairs of non-setose pleopods described in the previous Furcilia stage. In the (*f*) larva the pleopods of the fifth pair were small hardly distinguishable buds, yet the first two pairs were definitely setose. The degree of development of the thoracic limbs indicated that the larva was certainly *E. superba*.

In this stage the rostrum is still evenly rounded without any median spine and does not reach nearly to the distal margin of the basal peduncular segment of the antennule (Fig. 17 *b*, *c*, *d*, *e*). There is a small lateral denticle on the postero-lateral corner of the carapace (Fig. 17 *a*). The telson is seven-spined terminally and has the postero-lateral spines unaltered (Fig. 18 *a*); that is to say, the innermost postero-lateral has not the

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a, lateral aspect of larva with all pleopods setose (× 12);
b, dorsal aspect of larva with all pleopods setose (× 14);
c, antennule and rostrum of larva with 3 setose, 2 non-setose pleopods (× 35);
d, antennule and rostrum of larva with 4 setose, 1 non-setose pleopods (× 35);
e, antennule and rostrum of larva with 5 setose pleopods (× 35);
f, uropod and telson of larva with 3 setose, 2 non-setose pleopods (× 35);
g, uropod and telson of larva with 4 setose, 1 non-setose pleopods (× 35);
h, uropod and telson of larva with 5 setose pleopods (× 35);
j, antenna of larva with 5 setose pleopods (× 35);
k, mandibular palps of larva with 5 setose pleopods (× 83);
l, first maxilla of larva with 5 setose pleopods, plumose condition of exognath bristles and spinules on terminal bristles of palp not indicated (× 165);
m, second maxilla of larva with 5 setose pleopods (× 35).

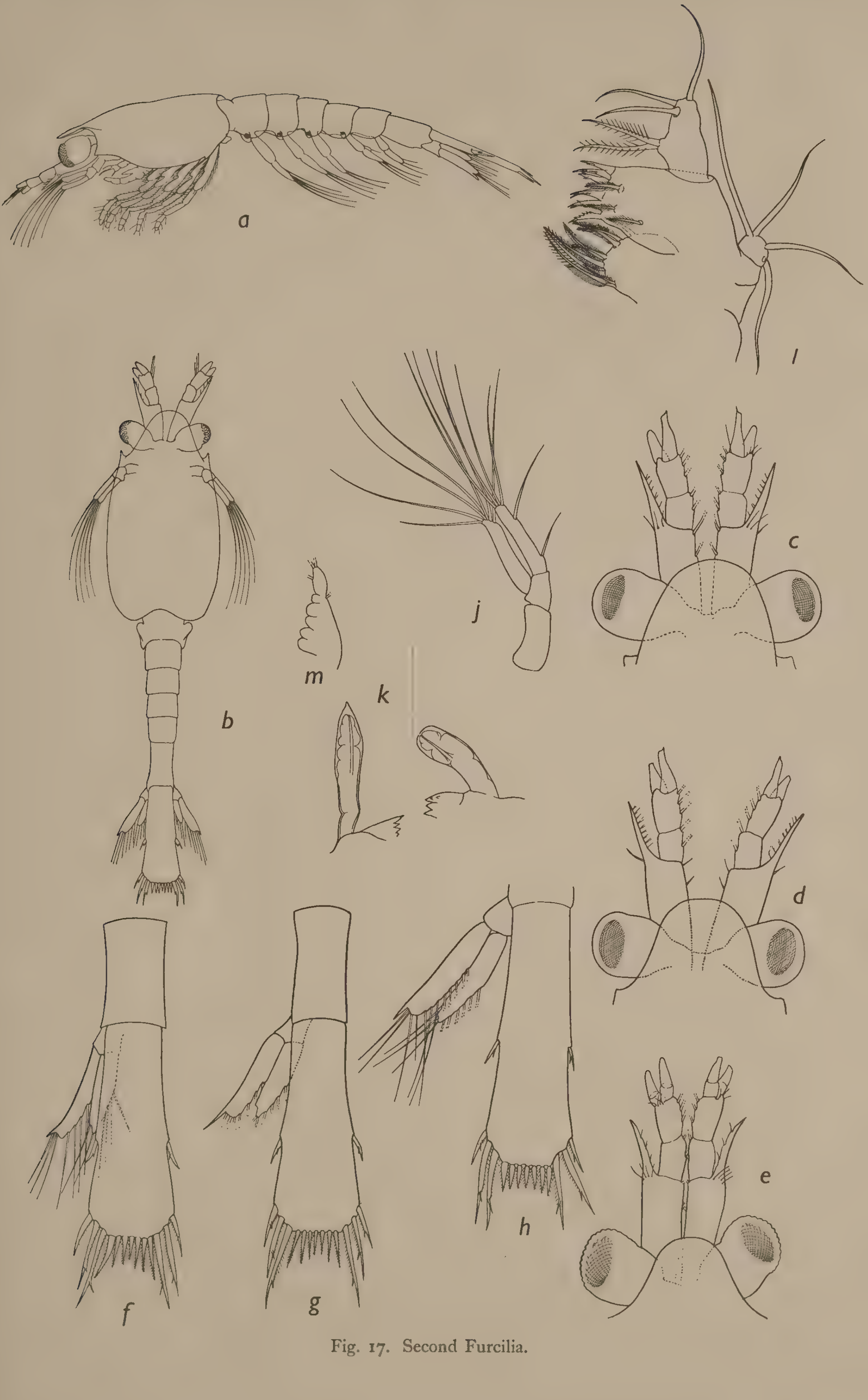
a
l
j
c
m
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Fig. 17. Second Furcilia.

Table XXX. *Occurrence of Second Furcilia*

Station	Date	Depth m.	No. of larvae	No. measured	Length range mm.	Average length mm.
(*a*) **3 pleopods: 2 setose, 1 non-setose**						
WS 527	30. iii. 30	250–100	8	2	3·96–4·04	4·00
(*b*) **4 pleopods: 1 setose, 3 non-setose**						
WS 527	30. iii. 30	250–100	4	1	4·58	4·58
(*c*) **4 pleopods: 2 setose, 2 non-setose**						
WS 527	30. iii. 30	250–100	4	1	4·54	4·54
(*d*) **4 pleopods: 3 setose, 1 non-setose**						
WS 527	30. iii. 30	250–100	4	1	4·50	4·50
(*e*) **4 pleopods: all setose**						
WS 527	30. iii. 30	250–100	32	8	4·63–5·29	4·86
WS 529	2. iv. 30	500–250	2	2	4·58–5·00	4·79
			34	10	4·58–5·29	4·84
(*f*) **5 pleopods: 2 setose, 3 non-setose**[1]						
661	2. iv. 31	360–0	1	1	4·79	4·79
(*g*) **5 pleopods: 3 setose, 2 non-setose**						
WS 527	30. iii. 30	100–50	2	1	4·38	4·38
		250–100	4	1	5·25	5·25
			6	2	4·38–5·25	4·82
(*h*) **5 pleopods: 4 setose, 1 non-setose**						
198	3. iv. 27	50–0	2	2	6·63–6·84	6·74
375	21. iii. 30	500–250	3	3	5·21–5·79	5·51
639	9. iii. 31	50–0	1	1	5·92	5·92
853	19. iv. 32	119–0	1	1	5·96	5·96
861	27. iv. 32	109–0	3	3	5·00–5·88	5·53
887	27. v. 32	120–0	2	2	5·08–5·33	5·21
WS 201	22. iv. 28	500–250	1	1	6·00	6·00
WS 202	23. iv. 28	500–250	2	1	5·50	5·50
WS 527	30. iii. 30	100–50	4	4	5·04–5·13	5·10
		250–100	116	29	4·58–5·58	5·06
WS 529	2. iv. 30	750–500	1	1	5·33	5·33
			137	49	4·58–6·84	5·47

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[1] This pleopod arrangement was found in one larva only, taken from a young Fish Trawl net and not from a 70-cm. vertical net.

Table XXX (*cont.*)

Station	Date	Depth m.	No. of larvae	No. measured	Length range mm.	Average length mm.
(*j*) **5 setose pleopods; spines on telson unaltered**						
199	3. iv. 27	500–250	5	5	6·33–6·83	6·62
200	4. iv. 27	300–250	1	1	6·83	6·83
201	5. iv. 27	50–0	2	2	6·46–7·00	6·73
		250–100	1	1	6·67	6·67
203	5. iv. 27	250–100	1	1	5·33	5·33
204	6. iv. 27	500–250	8	5	5·92–7·00	6·58
302	21. i. 30	250–100	1	1	6·92	6·92
303	21. i. 30	500–250	2	2	6·08–6·25	6·17
305	21–22. i. 30	250–100	1	1	6·46	6·46
319	29–30. i. 30	100–50	2	2	5·63–5·75	5·69
323	31. i. 30	500–250	2	2	5·63–6·00	5·82
335	4–5. ii. 30	50–0	1	1	6·00	6·00
338	5. ii. 30	225–100	1	1	6·08	6·08
342	7. ii. 30	500–250	3	3	6·17–6·83	6·61
343	7. ii. 30	250–100	1	1	6·46	6·46
353	9. ii. 30	250–100	1	1	6·63	6·63
354	9. ii. 30	500–250	1	1	6·75	6·75
360	24. ii. 30	50–0	1	1	5·83	5·83
361	25. ii. 30	50–0	1	1	5·75	5·75
		100–50	3	3	5·96–6·67	6·24
		250–100	140	50	5·83–7·33	6·62
362	25. ii. 30	50–0	7	7	6·46–7·29	6·75
		250–100	2	2	6·42–6·79	6·61
365	2. iii. 30	50–0	2	2	7·25–7·42	7·34
		250–100	2	2	7·17–7·29	7·23
368	8. iii. 30	50–0	1	1	7·00	7·00
		100–50	1	1	6·50	6·50
		250–100	12	12	6·25–7·08	6·56
369	9. iii. 30	50–0	1	1	6·92	6·92
		250–100	8	8	6·54–6·92	6·70
372	18. iii. 30	50–0	7	7	5·58–6·04	5·81
		100–50	3	3	5·63–5·92	5·74
373	19. iii. 30	50–0	1	1	6·17	6·17
374	20. iii. 30	50–0	1	1	5·67	5·67
375	21. iii. 30	500–250	8	8	5·21–6·67	5·91
635	7. iii. 31	50–0	1	1	5·92	5·92
855	20. iv. 32	125–0	8	8	6·54–6·96	6·75
		125–0	5	1	6·25	6·25
861	27. iv. 32	109–0	61	61	5·00–6·71	5·88
		270–138	44	44	5·25–7·00	6·06
862	28. iv. 32	102–0	6	6	5·63–6·38	5·99
887	27. v. 32	120–0	9	9	5·79–6·75	6·19
		86–0	19	19	5·92–6·71	6·30
		5–0	6	6	6·17–6·83	6·38
WS 199	20. iv. 28	500–250	17	15	6·29–7·21	6·74
WS 200	21. iv. 28	500–250	49	42	6·33–7·92	6·87
		750–500	3	2	6·54–7·17	6·86
WS 201	22. iv. 28	50–0	2	2	6·13–6·42	6·28
		250–100	1	1	5·42	5·42
WS 202	23. iv. 28	100–50	4	2	5·00–6·00	5·50
		250–100	2	2	5·29–6·46	5·88
WS 524	2. iii. 30	500–250	2	2	5·92–6·00	5·96
WS 527	30. iii. 30	50–0	8	2	5·21–5·75	5·48
		100–50	10	10	5·08–6·21	5·55
		250–100	224	56	4·63–6·33	5·59
WS 529	2. iv. 30	500–250	3	3	5·63–6·21	5·86
		750–500	3	3	5·63–6·13	5·95
			722	439	4·63–7·92	6·22

basal portion greatly broadened as in subsequent stages. The telson is from $2\frac{1}{2}$ to 3 times as long as its greatest width. The uropods extend to, or a very little way beyond, the lateral spines of the telson. The setae on the margins of the exopod and endopod are increased in number—as many as twelve being found on the outer ramus and ten on the inner ramus (Fig. 17 *f*, *g*, *h*).

ANTENNULE. The antennules are not altered in general structure, consisting as they do of three peduncular segments with two flagella distally (Fig. 17 *c*, *d*, *e*). The latter are unsegmented except in the largest larvae included in this stage (Fig. 17 *e*); in these the flagella may show faint indications of division into a proximal and distal segment. The sensory filaments of the flagella are situated away from the tip of the inner side of the outer flagellum. The forward spinous lateral projection of the basal peduncular segment does not extend as far as the distal margin of the distal peduncular segment. As in the previous stage it is armed with spinules along the inner margin. There are also several spinules around the base of this spine on the basal peduncular segment. The flagella are shorter than the combined lengths of the two distal peduncular segments.

ANTENNA. The antennae are still unchanged (Fig. 17 *j*).

MANDIBLE. In this stage the first signs of the changes in the mandible leading to the adult form become noticeable. The palp tends to be more elongate in the larger larvae; for example, in the larva with all pleopods setose it is an unsegmented digitiform process. The specimen figured shows segmentation within the integument and a long spine embedded in the soft tissues (Fig. 17 *k*). In the smaller larvae the palp is a short conical process similar to that found in earlier stages.

There are alterations in the tooth portion of the mandible which are most pronounced in the largest larvae. Sars (1885), referring to *Nyctiphanes australis* (p. 153), says in his description of the Calyptopis mandible:

> The armature of the cutting edges is well developed though somewhat dissimilar to that in the adult animal, resembling rather the armature found in some Mysidae. As it occurs in the latter the anterior part is divided into several strong, and very closely arranged, teeth forming together two partly superposed portions which in the two mandibles exhibit a somewhat different shape. Between this dentate part and the molar protuberance occurs a short dentiform projection, and at the base of the latter is affixed on both mandibles a very peculiar narrow plate expanded at the extremity and having the apical edge finely denticulate. This plate, wanting entirely in the adult animal, would appear to be movably connected with the mandible since it is very easily disengaged.

That part of the incisor process which could in the earlier stages be recognized as a pedunculated projection bearing small denticulations on the inferior border distally becomes reduced in size in the smaller larvae belonging to this stage (Fig. 18 *b*) and in the larger disappears altogether. The lacinia mobilis also is less conspicuous in the larger larvae of this furcilia stage.

FIRST MAXILLA. The general structure is as in 3rd Calyptopis, that is, consisting of a palp, outer and inner masticatory lobe and an exognath (Fig. 17 *b*). The advance in development from the previous stage is evident in the palp, which is now composed of a single segment, and in the masticatory lobes, where an increase in the number of spines has taken place. In the larva with three pairs of setose pleopods the outer lobe has eight marginal spines and one submarginal; the inner lobe spine number is unchanged. In the larva with four pairs of setose pleopods there are at least nine marginal spines on the outer masticatory lobe and a similar number on the inner. In the larva with all pleopods setose there are only eight marginal bristles on the outer masticatory lobe, but there are three submarginal bristles; on the inner there are nine marginal bristles.

SECOND MAXILLA. The 2nd maxillae are as in the previous stage (Fig. 17 *m*).

FIRST THORACIC LIMB. In the smaller larvae in this group the 1st thoracic appendage (Th. I) is as in previous stages, but in the larger larvae there is an advance in development marked by the elongation of the inner ramus and by its further segmentation into more than two. The endopod is never more than about twice as long as the exopod (Figs. 18 *c*, *d*, *e*).

THORACIC LIMBS II–VII. The thoracic limbs II–VI are much larger than Th. I. Also in this stage the flexion of the limbs which is found in adults becomes noticeable; that is to say, in the endopod the two proximal segments are directed forwards and downwards, and the three distal segments reflexed so that they point downwards and backwards. Of the larvae examined that having three pairs of setose pleopods has the thoracic limbs IV–VI of the form shown in Fig. 18 *c*. The 2nd thoracic limb endopod is longer than the 1st but shorter than Th. III or Th. IV which are the most developed of these appendages. The fifth limb endopod is indistinctly five-segmented, and the sixth, which is much the shortest, is still "sausage-shaped" and not so densely setose as the more anterior limbs. The setae on the endopods, which are chiefly situated along the inner margin of the limb, are of two kinds—short plumose setae projecting inwards, and longer plumose setae directed anteriorly. This applies to the proximal segments of the endopod; the distal three segments are not so heavily setose. The exopods, with the exception of the VIth, are more lamellar in form than in the previous stage; setae are present on the outer and inner margins as well as on the tips. In Th. III, IV and V the exopod shows the beginning of differentiation into two portions, a distal natatory part and, proximally, a strongly muscular portion. The distinction is noticeable in the outer margin by the formation of a shoulder-like projection about the middle of this edge, and on the inner margin by a curved projection near the base.

In the larvae with four pairs of setose pleopods there is an increase in the number of setae on exopods and endopods (Fig. 18 *d*). The endopod of Th. VI is segmented into four and the exopod is more lamellar in form than in the smaller larva with three pairs of pleopods. Situated behind Th. VI is a very small inconspicuous protrusion—the first rudiment of Th. VII.

In the largest larva—that having five pairs of setose pleopods—the endopods of the limbs II–VI are all distinctly five-segmented and the exopods are clearly divided into two portions, a distal natatory part and a proximal muscular part (Fig. 18 *e*). Setae extend along both the outer and inner margins to the projections on these described above. Setae on the endopod are greatly developed. Fig. 18 *e* shows the inner margin of Th. V to illustrate the arrangement of the two sets of setae found in the two proximal

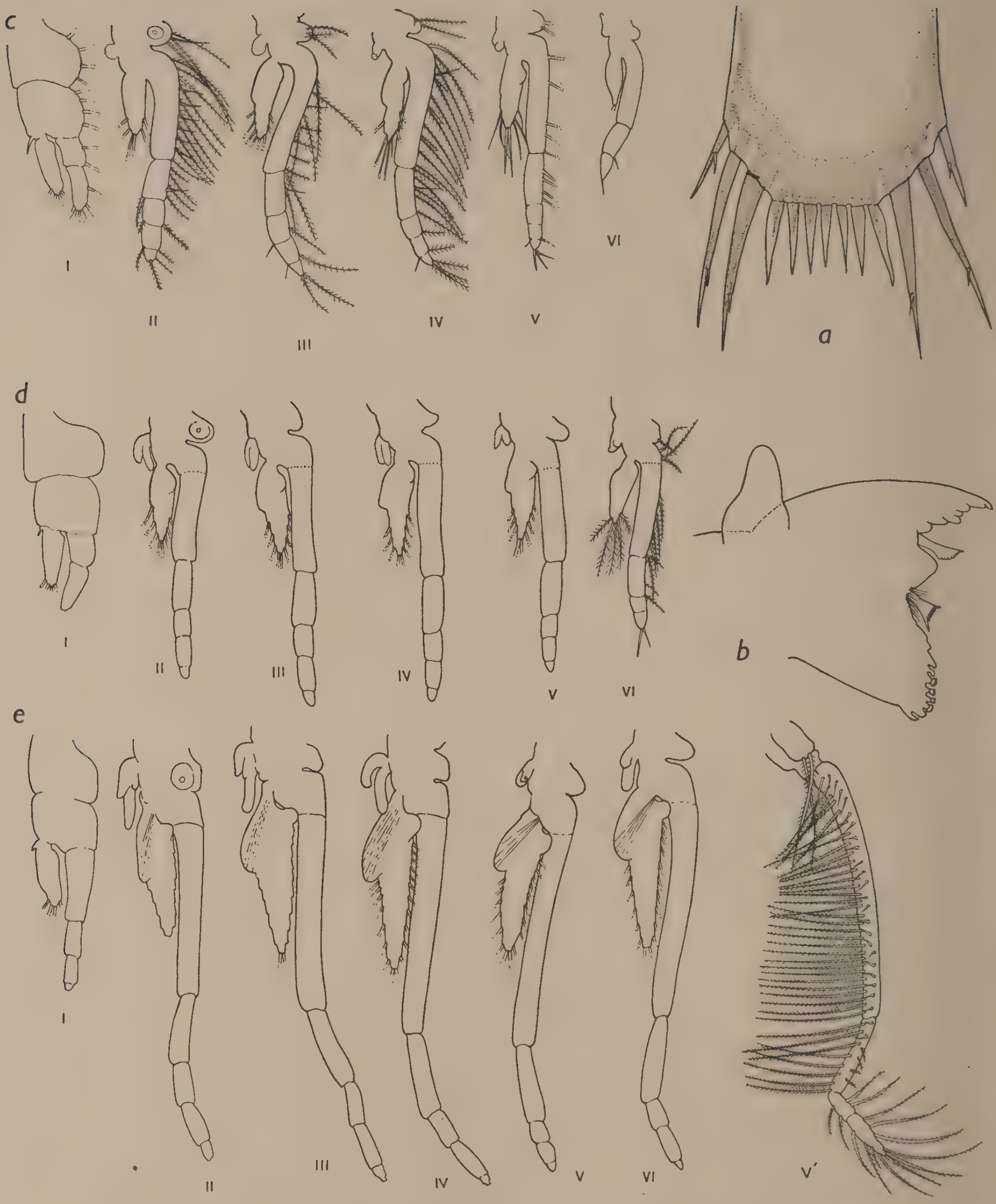

Fig. 18. Second Furcilia (continued).

a, telson of larva with 5 pairs of non-setose pleopods, spinules omitted (× 85);
b, mandible of larva with 3 setose, 2 non-setose pleopods (× 165);
c, thoracic limbs I–VI of larva with 3 setose, 2 non-setose pleopods (× 35);
d, thoracic limbs I–VI of larva with 4 setose, 1 non-setose pleopods, bristles on limbs omitted except on Th. VI (× 35);
e, thoracic limbs I–VI of larva with 5 pairs of non-setose pleopods, bristles omitted except V′ lateral view of Th. V, drawn to show inner aspect of limb (× 35).

segments; it also shows the natural flexion of the limb which is typical of thoracic appendages from this stage onward to the adult. Between Th. VI and the first abdominal segment, in the larva having five pairs of setose pleopods, there is a small process on each side, which is flattened antero-posteriorly and is the vestige of Th. VII (Fig. 19 *a*). In this aspect it appears roughly semicircular in outline with a small emargination near the external border. The ill-defined outer lobe is the developing gill, while in the inner part is the luminous organ belonging to this appendage which will develop in the next stage.

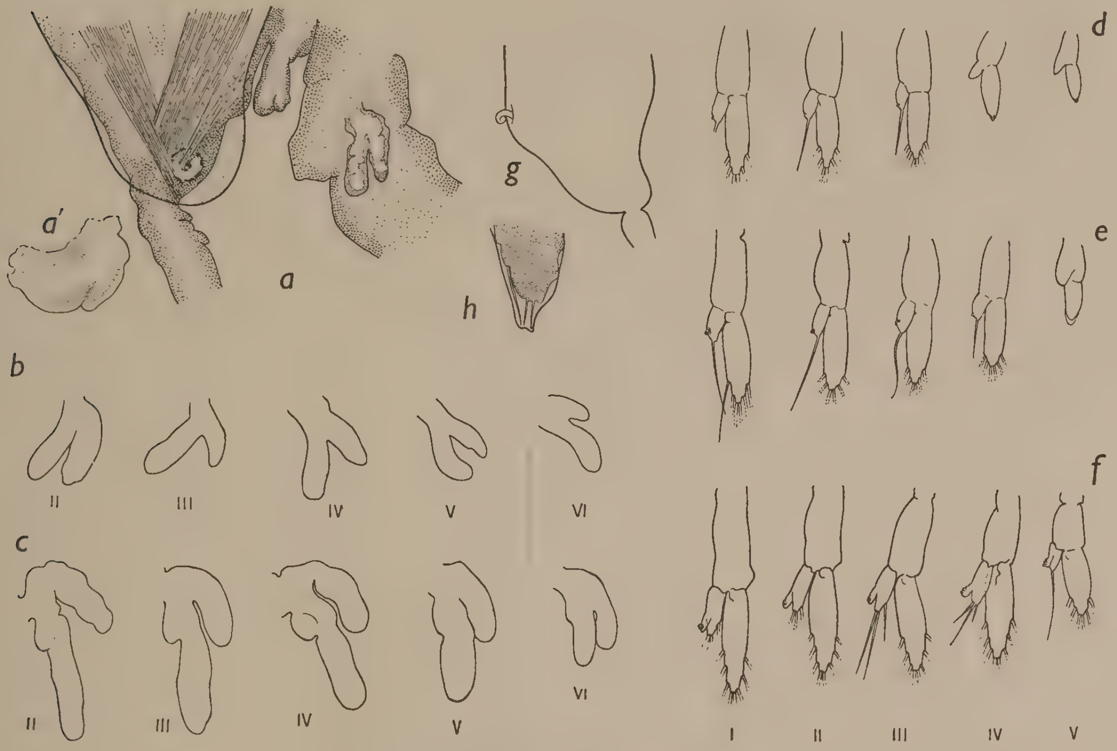

Fig. 19. Second Furcilia (continued).

a, lateral view of bases of thoracic limb VI and pleopod I with, between them, thoracic limb VII, *a′* Th. VII seen from behind (× 83);
b, gills on thoracic limbs II–VI in larva with 4 setose, 1 non-setose pleopods (× 83);
c, gills on thoracic limbs II–VI in larva with 5 setose pleopods (× 83);
d, pleopods I–V in larva with 3 setose, 2 non-setose pleopods (× 35);
e, pleopods I–V in larva with 4 setose, 1 non-setose pleopods (× 35);
f, pleopods I–V in larva with 5 setose pleopods (× 35);
g, appendix interna (× 360); *h*, setae within the integument of a non-setose pleopod (× 165).

Gills. In the smaller larvae included in this stage the gills are at much the same stage of development as in the larva having five pairs of non-setose pleopods, the only advance noted in the larva having three pairs of setose pleopods is that the gill of Th. V is now bilobed. In the larva with four pairs of setose pleopods the branchiae of Th. II–VI are all distinctly bilobed (Fig. 19 *b*). The gills of Th. II–VI in the larva with all pleopods setose have increased in size and show the beginnings of a third lobe at the base of the inner lobe (Fig. 19 *c*). The gill of Th. VII has already been described in connection with the limb rudiment. There is no sign in this Furcilia stage of a gill on the 1st thoracic limb.

Pleopods. The variety of pleopod forms within this stage is indicated in the list at the beginning of this section. The appearance of the pleopods in larvae having respectively three, four and five pairs setose is shown in Fig. 19 *d*, *e*, *f*. The non-setose pleopods are typically as in the larger larvae in the preceding stage, that is, having the exopod marked off from the protopodite and the endopod merging into it. Within the integument of the non-setose pleopods there can be distinguished the setae with which the exopod will be furnished when the larva moults (Fig. 19 *h*). The setose pleopods have six to eight setae on the exopod, which is now divided off from the protopodite, and from one to three setae on the endopod. At this stage the appendix interna appears on the inner margin of the endopods of those pleopods which are setose (Fig. 19 *g*). In the smaller larvae it is represented by a small hook-like process on the endopod, whilst in the larva with five setose pleopods a number of these hooks are borne on a digitiform projection from the inner margin of the endopod.

Luminous organs. In addition to those on the ocular peduncle and at the base of Th. II there are the following unpaired luminous organs distinguishable between the pleopods:

The larva having
2 setose pleopods and 3 non-setose has luminous organs on abdominal segments 1 and 2.
3 setose pleopods and 2 non-setose has luminous organs on abdominal segments 1, 2 and 3.
4 setose pleopods and 1 non-setose has luminous organs on abdominal segments 1, 2, 3 and 4.
5 setose pleopods has also four abdominal luminous organs.

The development of the luminous organs on the abdominal segments thus coincides with the development of setae on the pleopods.

The luminous organ on Th. VII cannot yet be distinguished.

THIRD FURCILIA

The reasons for recognizing this form of larva as a separate stage are given above on pp. 41–9. The frequency of occurrence of these larvae and their average lengths at different stations are stated in Table XXXI. For all the 3rd Furcilia the average length is 7·32 mm., and the range lies between 5·79 and 8·75 mm.

The two previous Furcilia stages are recognizable by the number and degree of development of the pleopods. In this stage other criteria must be adopted, as the pleopods have reached their full number and are all setose as in the largest larvae of the preceding stage. The most convenient character for this purpose is the form and number of the telson spines; the number is the same as in the earlier Furcilia stages, but the innermost postero-lateral spine, as shown in Fig. 20 *c*, is altered, being greatly widened at the base. Other distinctions in development in this Furcilia stage will be mentioned below.

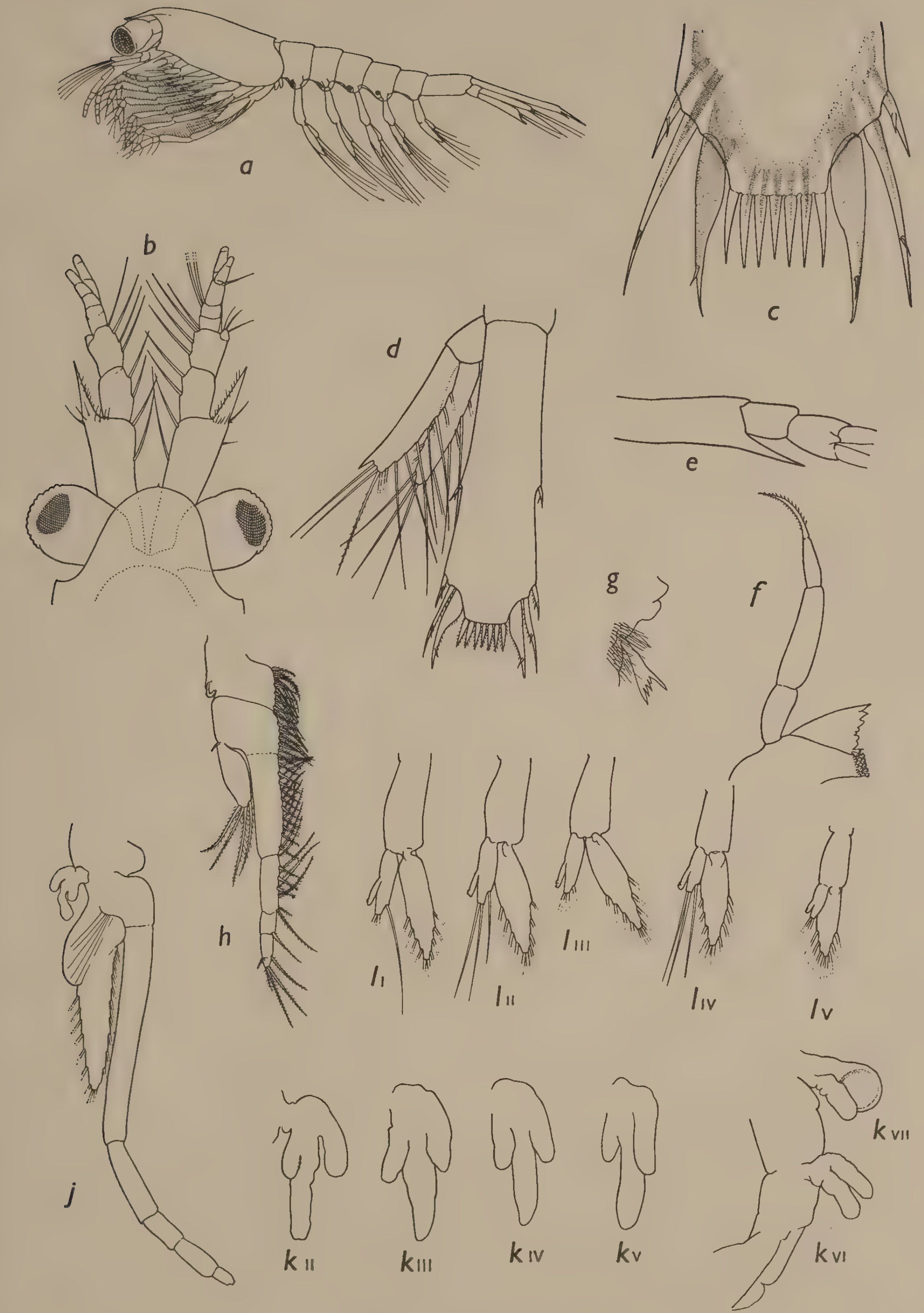
a
b
c
d
e
f
g
h
j
l I
l II
l III
l IV
l V
k II
k III
k IV
k V
k VI
k VII

Fig. 20. Third Furcilia.

a, lateral aspect (× 9);
b, rostrum and antennules (× 35);
c, telson, lateral spinules (× 85);
d, uropod and telson (× 35);
e, antennule (× 35);
f, mandible (× 83);
g, lacinia mobilis (× 360);
h, thoracic limb I showing arrangement of bristles (× 35);
j, thoracic limb III (× 35);
k, gills I–VII, base of Th. VI with Br. VI shown entire, Th. VII consisting of luminous organ and gill (× 83);
l, pleopods I–V (× 35).

Table XXXI. *Occurrence of Third Furcilia*

5-setose pleopods: spines on telson altered

Station	Date	Depth m.	No. of larvae	No. measured	Length range mm.	Average length mm.
194	28. iii. 27	50–0	1	1	7·29	7·29
197	3. iv. 27	100–50	7	7	7·29–8·17	7·70
		1000–750	1	1	8·00	8·00
198	3. iv. 27	50–0	4	3	7·42–8·13	7·74
		100–50	5	4	7·42–7·83	7·64
199	3. iv. 27	50–0	1	1	7·50	7·50
		250–100	1	1	7·58	7·58
		500–250	19	17	7·00–7·92	7·45
		750–500	21	21	6·75–8·00	7·41
200	4. iv. 27	300–250	2	2	7·58–7·71	7·65
201	5. iv. 27	50–0	3	3	7·08–7·58	7·32
203	5. iv. 27	50–0	6	4	7·04–7·79	7·43
		100–50	1	1	8·00	8·00
		250–100	1	1	7·71	7·71
204	6. iv. 27	500–250	13	13	6·92–7·67	7·28
206	6. iv. 27	250–100	1	1	7·00	7·00
304	21. i. 30	500–250	2	2	7·58–7·63	7·61
337	5. ii. 30	250–100	1	1	7·54	7·54
360	24. ii. 30	50–0	1	1	7·38	7·38
361	25. ii. 30	250–100	16	8	8·00–8·75	8·46
362	25. ii. 30	50–0	1	1	8·04	8·04
368	8. iii. 30	250–100	1	1	8·25	8·25
369	9. iii. 30	50–0	1	1	8·08	8·08
		250–100	1	1	8·25	8·25
372	18. iii. 30	50–0	3	3	7·08–7·29	7·11
		100–50	1	1	6·96	6·96
373	19. iii. 30	50–0	1	1	7·58	7·58
374	20. iii. 30	50–0	9	9	6·38–7·58	6·99
		100–50	1	1	7·63	7·63
375	21. iii. 30	50–0	1	1	6·67	6·67
		500–250	10	10	6·25–7·63	6·92
855	20. iv. 32	125–0	2	2	7·58–7·67	7·63
861	27. iv. 32	109–0	29	29	6·67–7·83	7·27
		270–138	28	28	6·71–8·15	7·26
862	28. iv. 32	102–0	3	3	7·04–7·38	7·20
		220–98	1	1	6·71	6·71
887	27. v. 32	120–0	4	4	6·58–6·96	6·75
		86–0	5	5	6·58–8·04	6·96
		5–0	7	7	6·67–7·21	6·87
888	28. v. 32	98–0	23	18	6·92–7·50	7·29
		240–90	1	1	7·13	7·13
WS 199	20. iv. 28	500–250	3	3	7·33–8·04	7·74
WS 200	21. iv. 28	500–250	13	13	7·75–8·50	8·21
WS 201	22. iv. 28	50–0	1	1	7·33	7·33
WS 427	28. iv. 29	50–0	1	1	7·08	7·08
WS 527	30. iii. 30	50–0	12	3	6·75–7·08	6·94
		100–50	1	1	6·58	6·58
		250–100	16	4	5·79–6·79	6·46
WS 529	2. iv. 30	500–250	13	13	6·33–7·42	7·02
		750–500	29	29	5·92–7·67	6·99
			329	289	5·79–8·75	7·32

The carapace is, with minor modifications, as in the previous stage (Fig. 20 *a*). The posterior margin is more concave and the rostrum slightly more elongate (Fig. 20 *b*), but the latter is still rounded anteriorly except for a minute spine which may or may not be present on the apex of the anterior border.

The telson is seven-spined terminally and has the modification (Fig. 20 *c*) of the postero-lateral spine just mentioned. The length of the telson is about $3\frac{1}{3}$ times the width. The uropods extend beyond the lateral spines of the telson and are more setose, having in the specimen figured thirteen setae on the outer ramus and twelve on the inner (Fig. 20 *d*).

ANTENNULE. The flagella of the antennules are multi-articular: in the specimen figured five segments are found (Fig. 20 *b*). They are roughly equal in length to the two distal peduncular segments. The spine on the outer margin of the basal peduncular segment is shorter than in the preceding stage, extending not more than about two-thirds of the length of the distal peduncular segment (Fig. 20 *e*).

ANTENNA. The antennae are still unchanged.

MANDIBLE. The palp (Fig. 20 *f*, *g*) is three-segmented with a long terminal spine. The variations in form of this appendage in this stage are dealt with in another section (p. 65). The lacinia mobilis is still present with fine hairs surrounding the base.

FIRST MAXILLA. The palp of the 1st maxilla is unsegmented and has two extra bristles on the inner margin, making seven bristles in all. The outer masticatory lobe in the specimen examined has nine marginal and two submarginal bristles. The inner masticatory lobe has ten bristles, five of which are heavily setose and more robust, the remainder slighter, smaller, and only finely plumose. The exognath is unchanged. The divisions separating the 1st and 2nd segments of the protopodite (sympod) cannot be distinguished in this or in earlier stages, although a suggestion of such segmentation was indicated in the 3rd Calyptopis.

SECOND MAXILLA. The 2nd maxillae are unchanged.

FIRST THORACIC LIMB. The endopod of this appendage is definitely five-segmented, armed with numerous bristles and about three times as long as the exopod (Fig. 20 *h*). The joint between the basal segment and the 1st endopod segment is very indistinct in this as in all the other limbs. The exopod is still primitive in form, bearing four bristles distally.

THORACIC LIMBS II–VII. The thoracic appendages II–VI are proportionately more elongate than in the previous stage. The exopods are rather longer in relation to the most proximal segment of the endopod and more setose than in the previous stage. Only Th. III has been figured to show the size compared with Th. I (Fig. 20 *j*). Th. II is still very slightly shorter than Th. III–VI. Th. VII is represented by two portions made up of a branchial lobe externally and a luminous organ internally (Fig. 20 *k*). There is no trace of Th. VIII at this stage.

GILLS. The gill on Th. I is small and inconspicuous. Those on Th. II–V are trilobed, having the central branch longer than the remaining two. The gill of Th. VI is bilobed with the beginnings of a third at the base of the inner lobe, and that on Th. VII is a single lobed process bearing the luminous organ on the peduncle (Fig. 20 *k*).

PLEOPODS. All the pleopods are setose, proportionately longer than in the preceding stage and have the endopod longer in relation to the exopod (Fig. 20 *l*). The pleopods are more setose, with eight to ten setae on the exopod instead of six to eight as in the largest larvae of the preceding stage. Pleopod V is more nearly similar to the remainder, but the inner ramus is still less developed than the others. The appendix interna is a digitiform process furnished with hooks.

LUMINOUS ORGANS. In addition to the light organs present on the largest larva belonging to the previous stage, the organ of Th. VII can now be distinguished (Fig. 20 *k* vii).

Table XXXII records the occurrence of larvae having six terminal spines on the telson. As stated on p. 51 above, larvae with an even number of terminal spines are in their general structure intermediate between those having respectively one more and one fewer telson spines. The infrequency of occurrence of the six spined form compared with those having seven and five shows that the former number must be regarded as a rare abnormality.

Table XXXII. *Occurrence of Furcilia larvae with six terminal spines on the telson*

Station	Date	Depth m.	No. of larvae	No. measured	Length range mm.	Average length mm.
197	3. iv. 27	100–50	2	2	8·54–8·92	8·73
374	20. iii. 30	50–0	7	7	6·46–7·54	7·19
375	21. iii. 30	500–250	2	2	6·88–7·08	6·98
862	28. iv. 32	102–0	3	3	7·29–7·63	7·45
WS 527	30. iii. 30	50–0	1	1	7·38	7·38
			15	15	6·46–8·92	7·43

FOURTH FURCILIA

The frequency of occurrence and average lengths of larvae belonging to this stage are stated in Table XXXIII. The average length of all the larvae is 8·01 mm., and the range between 6·67 and 9·92 mm.

The rostrum (Fig. 21 *a*, *b*) is more elongate and narrower than in the previous stage and may have a small denticle at its apex. The lateral denticle is present.

The telson (Fig. 21 *d*) is about four times as long as broad, bearing five terminal spines and three postero-lateral spines. The innermost postero-lateral is more modified than in the previous stage (Fig. 21 *c*); the broadened portion extends much nearer to the tip and the setae are missing from the inner margin proximally. The uropods extend beyond the lateral spines on the telson and may have one or two more setae than in the previous stage.

ANTENNULE. The flagella are multi-articulate and rather longer than the two distal peduncular segments. The spine on the outer margin of the basal peduncular segment extends to about the middle of the distal segment (Fig. 21 *b*). A lateral view of the peduncular segment is shown in Fig. 21 *e*.

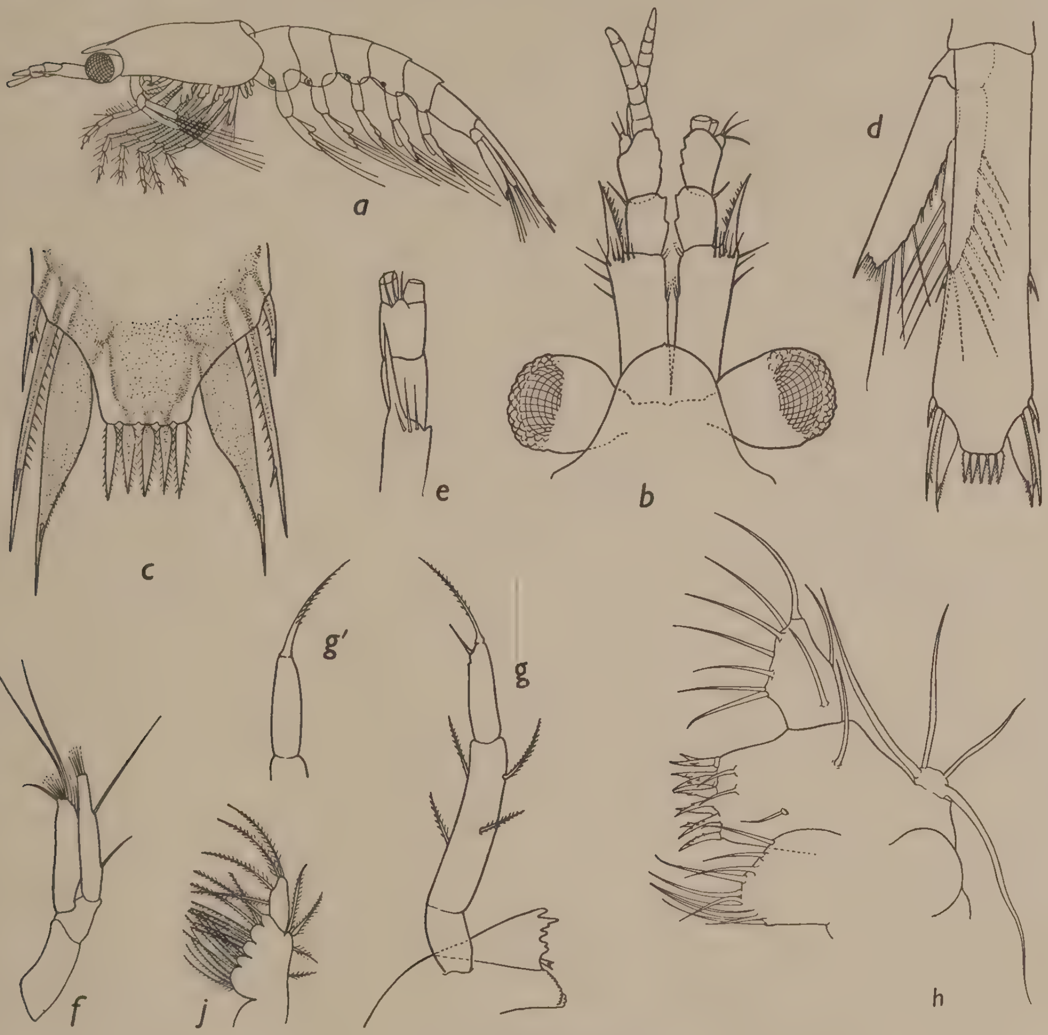

Fig. 21. Fourth Furcilia.

a, lateral aspect (× 9);
b, rostrum and antennules (× 35);
c, telson (× 83);
d, uropod and telson (× 35);
e, antennule, lateral view (× 35);
f, antenna (× 35);
g, mandible (× 83): *g'*, tip of palp (× 83);
h, first maxilla, spinules on bristles omitted (× 110);
j, second maxilla (× 35).

ANTENNA. There is only a faint indication in the antennae of differentiation into a scale and flagellum in the specimen figured (Fig. 21 *f*), but the variations in the form of this appendage are dealt with on p. 60. In this specimen the endopod is broader in proportion to its length than in earlier stages, but the number of bristles is unchanged.

Table XXXIII. *Occurrence of Fourth Furcilia*

5 terminal spines on telson

Station	Date	Depth m.	No. of larvae	No. measured	Length range mm.	Average length mm.
196	3. iv. 27	50–0	1	1	8·16	8·16
197	3. iv. 27	100–50	6	6	8·58–9·46	9·12
198	3. iv. 27	50–0	5	4	8·38–8·75	8·55
199	3. iv. 27	50–0	1	1	8·58	8·58
		500–250	2	2	8·54–9·17	8·86
203	5. iv. 27	50–0	5	3	8·33–8·88	8·65
204	6. iv. 27	500–250	3	1	8·75	8·75
361	25. ii. 30	100–50	1	1	9·75	9·75
372	18. iii. 30	50–0	9	9	7·04–9·38	8·04
		100–50	2	2	7·00–7·38	7·19
373	19. iii. 30	50–0	6	6	7·08–9·29	7·92
374	20. iii. 30	50–0	21	21	7·13–9·92	7·74
		100–50	3	3	7·38–9·17	8·02
375	21. iii. 30	50–0	2	1	7·71	7·71
		500–250	19	19	7·00–9·25	7·96
861	27. iv. 32	109–0	19	19	7·75–9·33	8·74
		270–138	3	3	7·75–9·29	8·50
862	28. iv. 32	102–0	38	38	6·67–8·08	7·41
		220–98	2	2	7·50–8·13	7·82
887	27. v. 32	120–0	1	1	7·50	7·50
		86–0	8	8	7·67–8·83	8·19
		0–5	2	2	7·67–9·04	8·36
		235–115	1	1	8·33	8·33
888	28. v. 32	98–0	1	1	8·42	8·42
912	24. vi. 32	2–0	16	2	7·63–8·71	8·17
WS 427	28. iv. 29	100–50	2	2	7·79–7·88	7·84
WS 527	30. iii. 30	50–0	80	20	7·42–8·46	7·81
		100–50	2	2	6·83–8·33	7·08
WS 529	2. iv. 30	500–250	18	18	7·42–8·83	8·28
		750–500	10	10	7·08–8·58	7·93
			289	209	6·67–9·92	8·01

MANDIBLE. The lacinia mobilis is still present in the mandible. The palp is three-segmented, and in the specimen figured has two spines on the apex of the distal segment of the one, and only one on the other (Fig. 21 *g*). The variation in the number of spines in the distal segment is dealt with on p. 65.

FIRST MAXILLA. The palp of the 1st maxilla is unsegmented with seven bristles from the apex along the inner margin. There are two less conspicuous bristles on the outer side of the palp. The masticatory lobes are very similar to those found in the previous stage but with ten marginal bristles on the outer lobe. The pseudexopod rudiment is visible but not conspicuous in the region of the larval exognath (Fig. 21 *h*).

SECOND MAXILLA. The terminal palp of the 2nd maxilla (Fig. 21 *j*) has four bristles extending from the tip along the inner margin. On the outer side of the maxilla, where the palp is articulated, there is a little rounded process bearing two setae: this is the exopod. The segmentation of this appendage into three basal segments (*vide* Hansen's *Studies on Arthropoda*, II, 1925, pl. xii) is not clear.

First thoracic limb. The form of the 1st thoracic appendage (Fig. 22 *a*) is not much altered, the endopod is five-segmented and heavily setose, and the exopod, as before, primitive in shape and bearing four bristles distally. The joint at the base of the endopod is not clear. The length of the limb is about three-quarters that of the succeeding thoracic appendage.

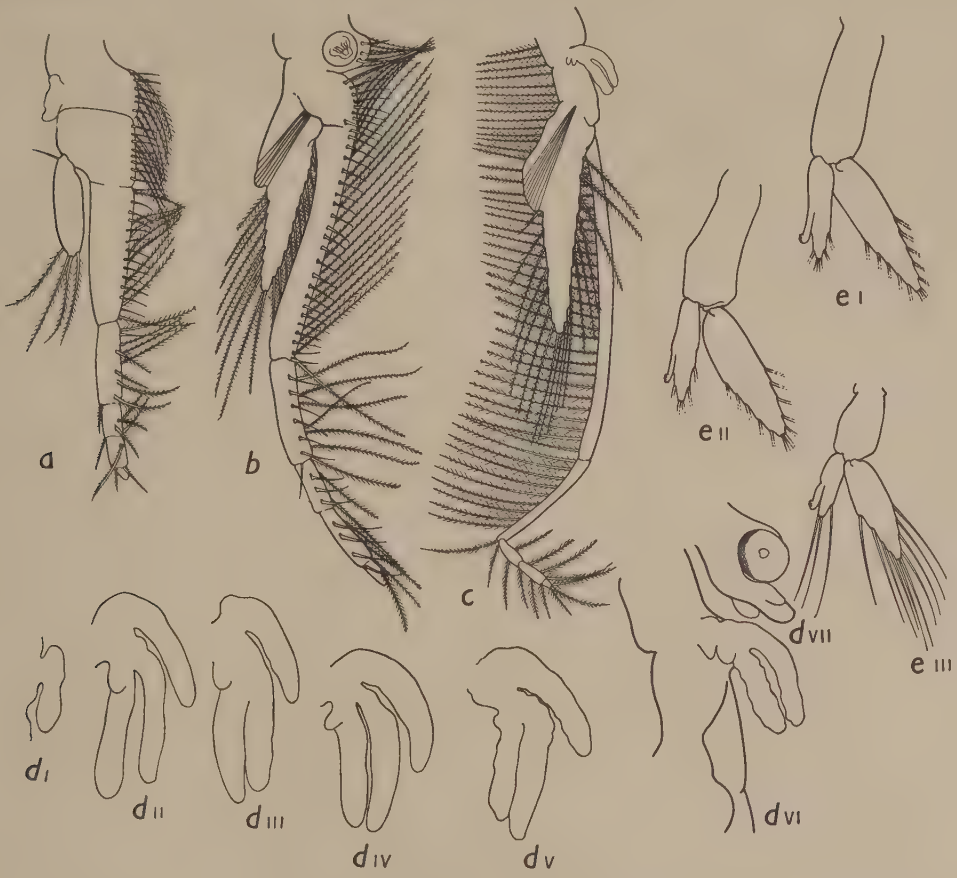

Fig. 22. Fourth Furcilia (continued).

a, thoracic limb I (×35);
b, thoracic limb II (×35);
c, thoracic limb VI, lateral aspect (×35);
d, gills I–VII, the base of Th. VI and vestigial Th. VII in front of luminous organ (×83);
e i, *e* ii, *e* iii, pleopods I, II and III (×35).

Thoracic limbs II–VIII. Thoracic limbs II–VIII are not greatly changed (Fig. 22 *b*, *c*). The exopods bear the following numbers of setae:

Th. II	inner margin	11,	outer margin	7
III	,,	13	,,	8
IV	,,	13	,,	8
V	,,	13	,,	8
VI	,,	11	,,	7

Situated on the inner side of the 7th gill and anterior to the luminous organ is a small digitate process not apparently branchial in function which is the vestige of the

7th thoracic appendage. Occasionally larvae belonging to this stage are found in which the process has a little spine at its tip. Th. IV is drawn in lateral aspect to show the typical flexion in the thoracic limbs.

One large larva included in this stage had traces of the eighth limb just distinguishable.

GILLS (Fig. 22 *d*). The gill on Th. I is single lobed and small, although more noticeable than in the preceding stage. Gills II–V are trilobed as in the preceding stage, but with two of the three lobes in each gill more or less equal to each other and the third rather short. The formation of a fourth lobe can be seen at the base of the innermost lobe, and in gill II still another incipient lobe at the base of the existing middle lobe. Gill VI is still bilobed but much larger than previously and has two small rounded processes basally. Gill VII is bilobed.

PLEOPODS. The pleopods (Fig. 22 *e*) are unaltered in general structure but have increased the number of marginal setae, there being now ten to twelve instead of eight to ten on the exopods.

LUMINOUS ORGANS. All the luminous organs are present.

Table XXXIV shows the incidence of larvae with four terminal spines on the telson. The infrequency of occurrence of this form is comparable to that already noted (p. 88) in larvae having six terminal spines, and the remarks made concerning the latter form of larva are equally applicable to that having four terminal spines.

Table XXXIV. *Occurrence of Furcilia larvae with four terminal spines on the telson*

Station	Date	Depth m.	No. of larvae	No. measured	Length range mm.	Average length mm.
373	19. iii. 30	50–0	1	1	8·08	8·08
374	20. iii. 30	50–0	2	2	7·96–8·58	8·27
375	21. iii. 30	500–250	1	1	9·08	9·08
WS 427	28. iv. 29	50–0	1	1	9·00	9·00
			5	5	7·96–9·08	8·54

FIFTH FURCILIA

The frequency of occurrence of larvae of this form and their average lengths are stated in Table XXXV. The average length of all the larvae is 9·52 mm., and the range is between 8·25 and 11·50 mm.

The carapace (Fig. 23 *a*) has the rostrum less rounded and more angular in outline, and there is generally a distinct short broad spine at the apex. The lateral denticle on the carapace is more pronounced than in the previous stage.

The telson length is more than five times the breadth at the insertion of the smallest postero-lateral spine (Fig. 23 *c*). The posterior margin of the telson carries three spines on a border which is much narrower and more rounded than in the previous stage. In dorso-ventral aspect the telson as a whole tapers from in front tailwards, except in the region of the insertion of the postero-lateral spines where there is a slight widening. The innermost postero-lateral spines are widened over a greater portion of the length than previously but tapered distally to a point. A few small bristles are found on the inner margin near the tip, but the dorsally projecting spinule has disappeared. The uropods are more setose than in the previous stage.

Table XXXV. *Occurrence of Fifth Furcilia*

3 terminal spines on telson

Station	Date	Depth m.	No. of larvae	No. measured	Length range mm.	Average length mm.
372	18. iii. 30	50–0	14	14	8·75–10·42	9·72
		250–100	1	1	8·88	8·88
373	19. iii. 30	50–0	27	27	8·63–11·04	9·49
374	20. iii. 30	50–0	16	16	8·67–10·08	9·31
375	20. iii. 30	500–250	22	22	8·46–9·83	9·31
		50–0	2	—	—	—
393	20. iii. 30	150–75	1	1	9·54	9·54
861	27. iv. 32	109–0	2	2	9·58	9·58
		270–138	1	1	10·83	10·83
862	28. iv. 32	102–0	12	12	8·25–9·58	8·92
		220–98	2	2	8·67–9·17	8·92
887	27. v. 32	120–0	1	1	8·50	8·50
		86–0	1	1	9·04	9·04
912	24. vi. 32	0–2	376	47	9·00–11·50	9·84
WS 527	28. iv. 29	50–0	1	1	9·17	9·17
WS 529	2. iv. 30	500–250	8	8	9·17–10·13	9·66
		750–500	1	1	9·04	9·04
			488	157	8·25–11·50	9·52

ANTENNULE. The flagella are greatly elongated, being nearly twice as long as the two distal peduncular segments. The dorsal lobes on the distal margin (dorsally) of the first and second basal segments are more pronounced than formerly (Fig. 23 *b*, *d*). The lateral spine on the first segment is reduced in size; this segment bears a number of bristles dorsally and on the outer margin.

ANTENNA. The differentiation of the rami of the antenna into scale and flagellum is complete (Fig. 23 *e*). The outer ramus forms a roughly oblong lamella with bristles along the inner and distal margins. The inner ramus consists of two peduncular segments and one or more flagellar segments according to the size of the larva, as shown on p. 64. The peduncle is articulated with the second segment of the protopodite in such a way that it appears at first sight as if the inner ramus had three peduncular segments. The insertion of the scale low down on the side of the second protopodal segment emphasizes this appearance. The proximal segment of the protopodite has a spine projecting forwards from the outer corner.

MANDIBLE. The lacinia mobilis is still present but very small and degenerate. The

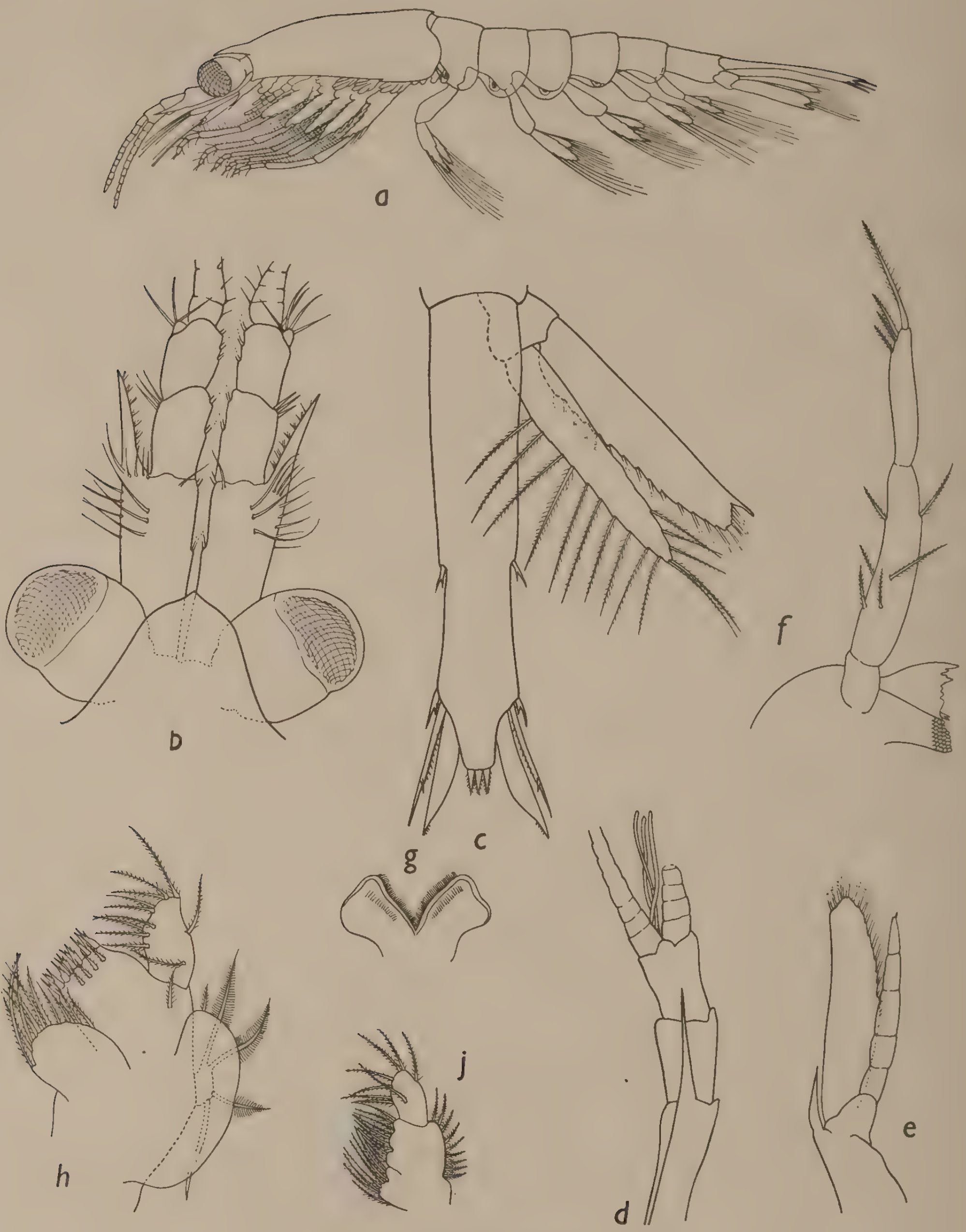

Fig. 23. Fifth Furcilia.

a, lateral aspect (×12);
b, antennules and rostrum (×35);
c, uropod and telson (×35);
d, antennule, lateral aspect (×35);
e, antenna (×35);
f, mandible (×60);
g, labrum (×35);
h, first maxilla (×83);
j, second maxilla (×35).

distal segment of the palp (Fig. 23 *f*) is longer and narrower than in the previous stage; the number of spines borne on it varies as shown on p. 67. The labrum is shown in Fig. 23 *g*.

First maxilla. The palp and masticatory lobes of the 1st maxilla (Fig. 23 *h*) have more bristles than in the previous stage. The pseudexopod is now a conspicuous lamellar structure completely covering the larval exopod, extending nearly to the insertion of the palp and bearing a small bristle on its margin. The larval exopod is visible through the pseudexopod.

Second maxilla. The palp is now broader in proportion to its length and has more bristles than in the previous stage (Fig. 23 *j*). The exopod is more conspicuous and furnished with about nine setose bristles. The two distal lobes on the inner margin of this appendage have partially coalesced so that only four distinct lobes are now apparent.

First thoracic limb. The 1st thoracic appendage (Fig. 24 *a* i) is still shorter than Th. II. The exopod has a greater number of spines than formerly but has not yet assumed the shape typical of the other exopods.

Thoracic limbs II–VIII. The setae on Th. II–VI are more abundant (Fig. 24 *a* ii, *a* iv). The vestige of Th. VII (Fig. 24 *b* vii) bears a small spine and that of Th. VIII is a small inconspicuous lobe set internally to the gill. In one very large three-spined larva Th. VII was a conical process with a rounded tip bearing two small bristles and Th. VIII a similar but smaller structure with one bristle.

Gills. The gill on Th. I is rather fusiform in shape and attached, not at its end, but at about one-third of the distance along one side (Fig. 24 *b* i). The gills of Th. II and III are four-lobed, of Th. IV and V five-lobed, of Th. VI four-lobed, of Th. VII three-lobed and of Th. VIII two lobed (Fig. 24 *b* ii–viii). In the last the two lobes are equal in length and much larger than in the previous stage. In the very large three-spined larva mentioned above the gill of Th. VII was four-lobed and that of Th. VIII three-lobed.

Pleopods. There is nothing to distinguish the pleopods (Fig. 24 *c* i, *c* ii, *c* v) from those in the previous stage except the number of setae which has increased so that there are now typically fourteen to sixteen on the exopods.

Table XXXVI records the occurrence of larvae with two terminal spines on the telson. This is the last of the aberrant telson forms. In its infrequency it is consistent with those which preceded it mentioned above on pp. 88 and 92.

Table XXXVI. *Occurrence of Furcilia larvae with two terminal spines on telson*

Station	Date	Depth m.	No. of larvae	No. measured	Length range mm.	Average length mm.
372	18. iii. 30	50–0	1	1	10·50	10·50
862	28. iv. 32	102–0	1	1	9·00	9·00
			2	2	9·00–10·50	9·75

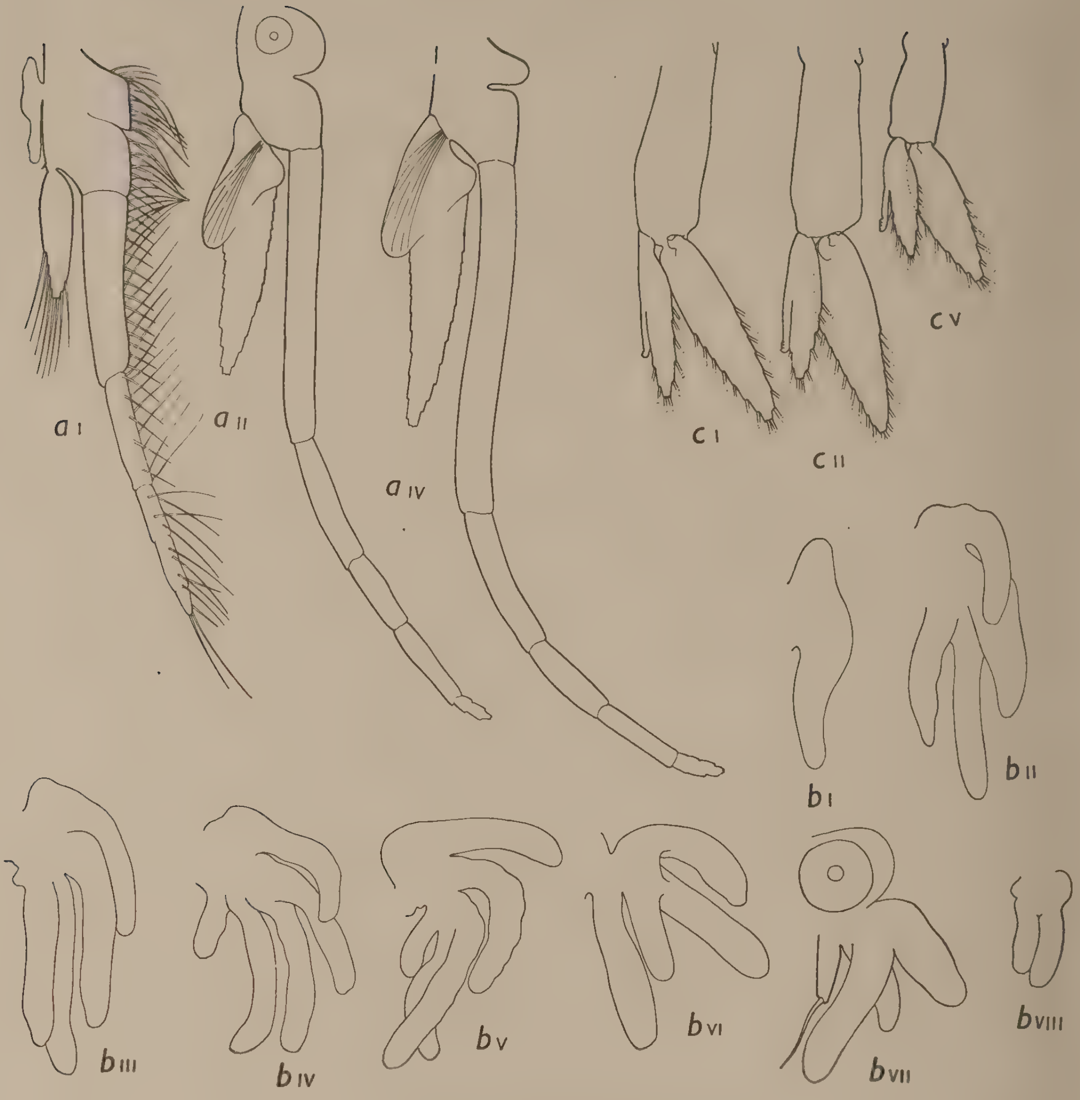

Fig. 24. Fifth Furcilia (continued).

a i, *a* ii, *a* iv, thoracic limbs I, II and IV (× 32); *b* i–*b* viii, gills (× 83), Th. VII shown with gill. *c* i, *c* ii, *c* v, pleopods I, II and V (× 35).

SIXTH FURCILIA

The frequency of occurrence and average lengths of larvae belonging to this stage are stated in Table XXXVII.

The rostrum (Fig. 25 *a*, *c*) is much more acutely pointed than in the previous stage. The lateral denticle is conspicuous, and the emargination of the posterior border of the carapace is as shown in Fig. 25 *a*.

The telson length is more than six times the width at the insertion of the smallest postero-lateral spines (Fig. 25 *b*). There is only one spine posteriorly, and with this condition the posterior border is reduced so that the lateral borders approximate to each other and are in alignment with the lateral borders of the median spine. Three postero-lateral spines are still present, the innermost flattened and wide throughout most of its length; the middle spine is rather reduced but bears the normal spinules on the inner and dorsal surfaces. The telson is roughly double the length of the sixth abdominal segment.

Table XXXVII. *Occurrence of Sixth Furcilia*

One terminal, three postero-lateral spines on telson

Station	Date	Depth m.	No. of larvae	No. measured	Length range mm.	Average length mm.
373	19. iii. 30	50–0	1	1	10·00	10·00
374	20. iii. 30	50–0	1	1	9·42	9·42
375	21. iii. 30	500–250	3	3	10·42–11·63	11·21
393A	7. v. 30	150–75	1	1	9·54	9·54
471	31. x. 30	50–0	33	33	9·50–15·00	11·76
477	13. xi. 30	50–0	2	2	11·00–12·50	11·75
483	14. xi. 30	50–0	17	17	10·50–14·50	11·96
		100–50	8	8	12·50–15·50	13·56
484	16. xi. 30	50–0	13	13	11·00–14·50	12·48
		100–50	1	1	13·25	13·25
862	28. iv. 32	102–0	4	4	9·25–10·33	9·79
912	24. vi. 32	2–0	1088	136	10·00–13·50	10·85
954	9. ix. 32	0–5	23	23	11·00–13·00	11·57
955	9. ix. 32	0–5	7	7	10·00–12·00	10·96
956	9. ix. 32	97–0	1	1	10·25	10·25
		280–100	1	1	11·25	11·25
957	10. ix. 32	0–2	2	2	10·50–13·00	11·50
959	11. ix. 32	0–5	3	3	11·50–12·50	11·75
		91–0	1	1	12·75	12·75
WS 255	22–23. viii. 28	50–0	1	1	8·96	8·96
WS 263	28. viii. 28	500–250	2	2	8·00–11·00	9·50
WS 266	29. viii. 28	750–500	1	1	9·20	9·20
		1000–750	1	1	11·50	11·50
WS 268	29. viii. 28	250–100	1	1	9·20	9·20
WS 270	30. viii. 28	50–0	1	1	10·80	12·30
WS 274	4. ix. 28	250–100	1	1	9·87	10·80
WS 275	4. ix. 28	100–0	2	2	9·37–10·37	9·87
WS 284	18. ix. 28	50–0	2	1	12·75	12·75
WS 286	18. ix. 28	50–0	5	5	10·00–13·00	11·15
WS 287	19. ix. 28	50–0	1	1	10·75	10·75
WS 304	6. x. 28	50–0	1	1	11·75	11·75
WS 307	7. x. 28	50–0	2	2	13·00–14·00	13·25
WS 310	8. x. 28	50–0	2	1	16·75	16·75
WS 527	30. iii. 30	50–0	8	2	10·08–10·29	10·19
WS 529	2. iv. 30	500–250	2	2	10·42–11·96	11·19
WS 573	25. iii. 31	50–0	1	1	9·80	9·80
			1244	284	8·00–15·50	11·34

ANTENNULE. The flagella are longer in proportion to the body length than those in the previous stage, but in preserved material they are usually broken off. Sensory filaments are present at the base of the outer flagellum. The lobes on the anterior margins of the basal segments are more pronounced (Fig. 25 *c*).

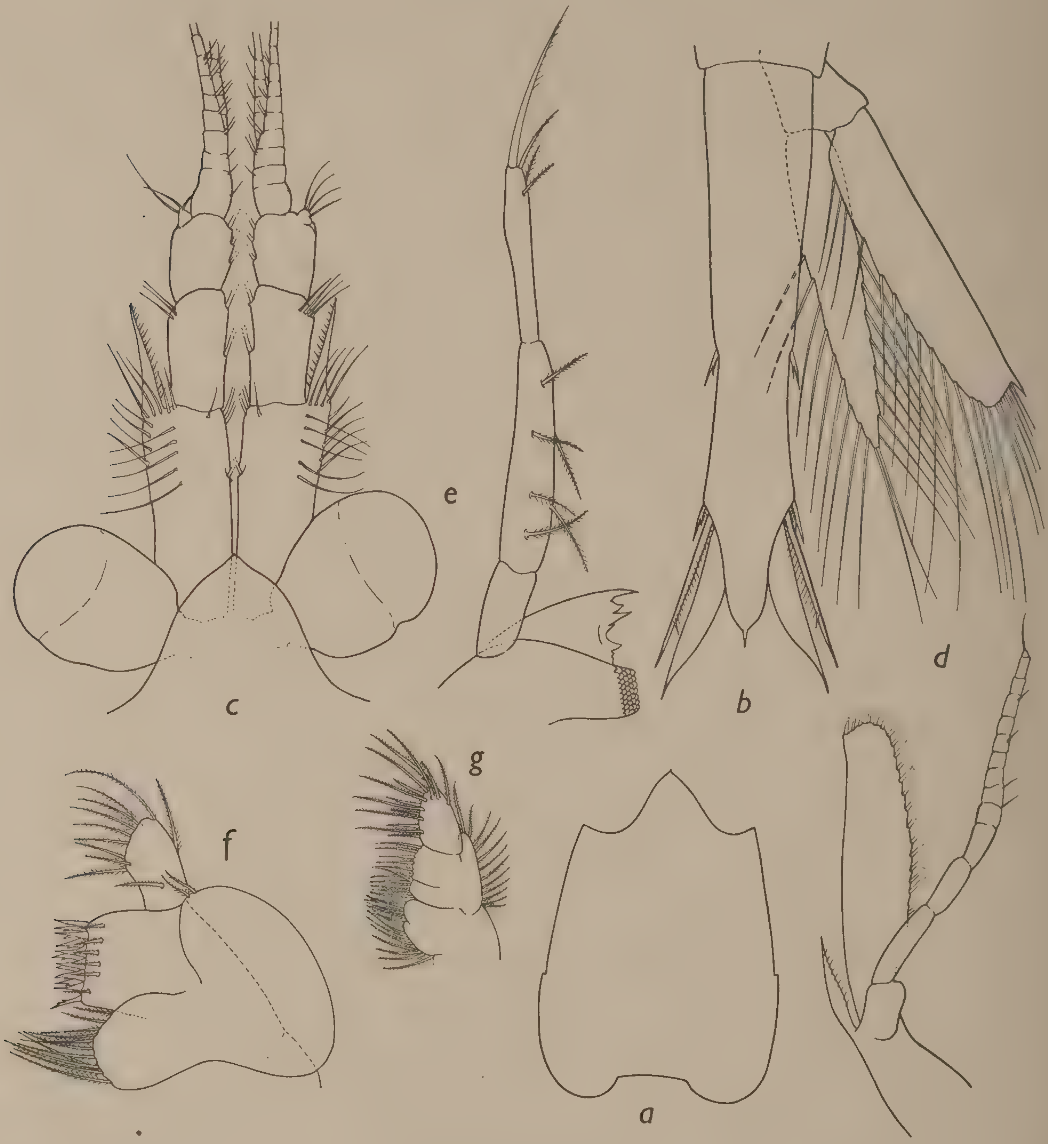

Fig. 25. Sixth Furcilia.

a, carapace (×13);
b, uropod and telson (×35);
c, antennules and rostrum (×35);
d, antenna (×35);
e, mandible (×60);
f, first maxilla (×83);
g, second maxilla (×35).

ANTENNA. The scale is more heavily furnished with setae on its inner margin than in the previous stage; the flagellum is multi-articulate and much longer than the scale (Fig. 25 *d*). The spine on the basal segment is furnished with little bristles on its inner margin. The second basal segment is indistinctly articulated with the first and appears like an additional peduncular segment of the inner ramus.

MANDIBLE. The lacinia mobilis has disappeared on the specimen figured, and in all the other larvae examined belonging to this stage no lacinia mobilis was seen. The palp (Fig. 25 *e*) is more elongate than in the previous stage and the number of spines on the distal segment is increased: the variations in spine number are dealt with on p. 67.

FIRST MAXILLA. The palp is slightly shorter and broader than in the previous stage, but the masticatory lobes are similar. The larval exopod has disappeared and the pseudexopod extends to the joint of the palp bearing on its margin two or three little bristles (Fig. 25 *f*).

SECOND MAXILLA. This appendage (Fig. 25 *g*) consists now of three portions: distally the palp, which is broader in proportion to its length than in the previous stage; a middle portion with two lobes internally and the digitate process of the exopod externally; and proximally a basal portion bearing two lobes internally.

FIRST THORACIC LIMB. The exopod of Th. I (Fig. 26 *a* i) has lost the larval form and has now a distinct "shoulder" on the outer margin. The number of bristles on the exopod has increased so that there are five on the outer margin and three on the inner.

THORACIC APPENDAGES II–VIII. The exopods of Th. II–VI show more clearly the articulation of the basal with the terminal part, and the natatory setae are increased in number. Only Th. VI is figured (Fig. 26 *a* vi). The endopod of Th. II is shorter than that of Th. III and there is a decrease in size from Th. III backwards. Th. VII (Fig. 26 *b* vii) is an inconspicuous process bearing two setae terminally and Th. VIII (Fig. 26 *b* viii) is a still smaller vestige which may or may not have a seta. Th. VII and VIII are figured along with the gills belonging to these appendages.

GILLS. The gill or epipodite of Th. I (Fig. 26 *b* i) is similar to that seen in the previous stage. The gills of the remaining thoracic limbs (Fig. 26 *b* ii–viii) are more developed than previously, those of Th. II and III are five-lobed, Th. IV is also five-lobed with indications of a further lobe developing. The gills of Th. V and VI are similar in development to those of the preceding stage. The gill of Th. VII has four well-developed lobes and two more short lobes developed in proportion to the size of the larva: two different conditions of this gill have been figured. The gill of Th. VIII has three large lobes and two small ones near the peduncle.

PLEOPODS. There is an increase in the number of marginal bristles (Fig. 26 *c* i, ii, v) and the appendix interna (Fig. 26 *d*) has four or five hooks.

ADOLESCENT FORMS

Rustad (1930, p. 68) gives reasons for the abandonment of the term "post-larval" to describe the stages which succeed those formerly classed as Cyrtopia. He states that the latter stages merge gradually into the adult and points out, what Dr Bargmann has also

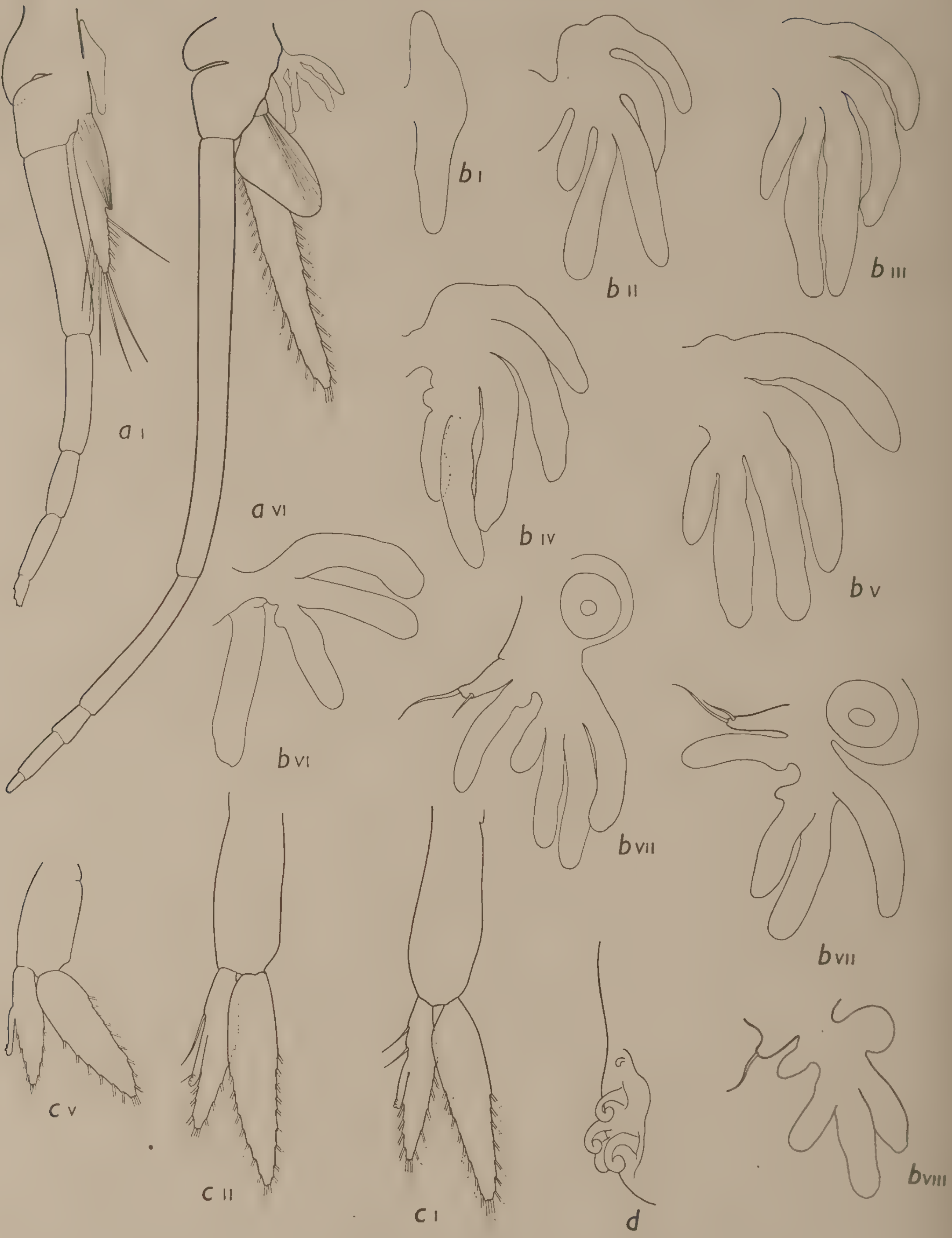
a i
a vi
b i
b ii
b iii
b iv
b v
b vi
b vii
b vii
b viii
c v
c ii
c i
d

Fig. 26. Sixth Furcilia (continued).

a i, thoracic limb I, bristles on endopod omitted (×35);
a vi, thoracic limb VI, bristles on endopod omitted (×35);
b i–*b* viii, gills I–VIII, two forms of gill VII showing Th. VII, *b* viii showing Th. VIII (×83);
c i, *c* ii, *c* v, pleopods I, II and V (×35); *d*, hooks on appendix interna (×165).

observed in *Euphausia superba*, that sexual maturity may be reached before the adult form is attained. It is proposed therefore in the present paper to use the term "adolescent" to describe that portion of development between the 6th Furcilia stage and the part of the life history where changes take place associated with sexual maturity. The scope of the paper, so far as adolescents are concerned, is limited to the younger individuals in this phase and does not include reference to those that from their size require special examination to decide whether they are adolescent or adult.

By the time the euphausiid reaches the 6th Furcilia stage the major developmental changes have been effected and in appearance it is characteristically a euphausian. Such alterations as take place subsequently chiefly involve the elaboration of existing structures, for instance, increase in the number of setae on the antennal scale, in the number of segments in the antennular flagellum, in the number of lobes on the branchiae, and so on. These changes are gradual and show great individual variation. Attempts which were made to arrange the adolescents in groups or stages dependent on the number of setae on the antennal scale did not yield any satisfactory results, and it was made obvious by inspection of the animals that in other appendages as well no hard and fast pattern of development exists.

It should be emphasized again that this generalized development is not an exclusive feature of the adolescents, but that it is incipient, in some characters at any rate, in early Furcilia stages and becomes more and more evident as development goes on. Thus although Furcilia 6 is recognized in the main by having one terminal and three postero-lateral spines on the telson, as opposed to two postero-lateral spines in the adolescent, yet the distinction between the two stages is diffuse and ill-defined.

In Appendix I the length frequencies of late Furcilia and early adolescents taken in the 1-m. nets have been set out. The time of year when the larvae were obtained, the total number and the number examined, the average length for each phase of development, the percentage of the total in each phase and the general average have been stated.

The first point to be noted from this analysis is that Furcilia 5, representing larvae about 8 mm. in length, although occurring in August and September is in such very small numbers that it may fairly be concluded that the vast majority of the larvae reach the Furcilia 6 stage before the end of the southern winter.

Inspection of the table shows that the total number of *E. superba* at different stations varies very greatly, and that the small numbers at some of the stations tend to give anomalous results. It is possible, however, to get an approximate indication of the relative abundance of the two phases of krill principally represented, namely Furcilia 6 and adolescent.

In Table XXXVIII the average percentage occurrence of Furcilia 6 is stated. The percentages from which these averages are derived are of catches where the number of euphausians examined was considered sufficiently high to give a trustworthy idea of the proportions in which Furcilia 6 and adolescents were present.[1]

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[1] The arbitrary number of 48 was selected.

Table XXXVIII. *Average percentage occurrence of the sixth Furcilia*

	1928–29	1929–30	1930–31
August	75	—	—
September	49	—	—
October	35	—	19
November	—	10	16
December	—	0	0
January	—	0	0

It is seen that there is a decrease from August to December from a stock three-quarters of which are Furcilia 6 to one in which this stage is not represented.

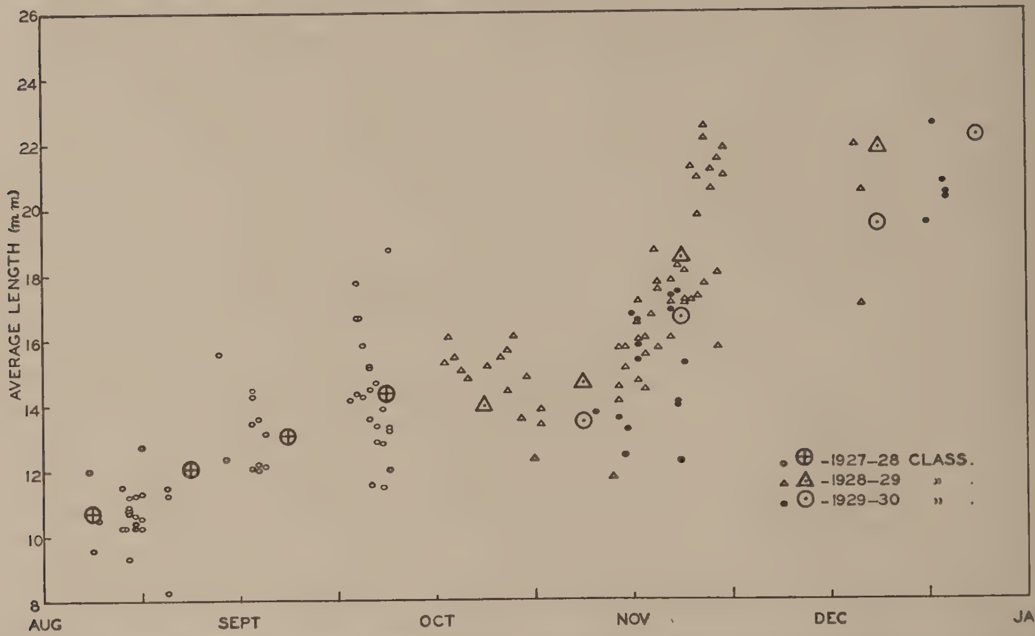

Fig. 27. Average length of second season krill. The smaller signs express average lengths of individual samples, the larger ones the half-monthly average lengths of all the young euphausians taken.

An impression of the length range of Furcilia 6 is easily obtained by reference to the appendix. The way in which the upper limit of length overlaps the lower limit of the adolescent size range emphasizes the indefinite nature of the division between the two phases of developmental history. The length range of Furcilia 6 covers 9 mm., extending from 8 to 17 mm. with a mean length of about 12 mm. But it is possible to get adolescents 10·5 mm. long, so that there is an overlap in the two length ranges of 6·5 mm.

In Fig. 27 the average lengths of the krill from the samples referred to above are depicted. The smaller signs express average lengths of individual samples and the larger ones the half-monthly average lengths of all the young euphausians taken. The three seasons' catches have been given the designation of classes, that is to say the 1927–8 class represents larvae which originated in that season. They would be adolescents in the 1928–9 season and adult in the succeeding season.

The figure shows the great range of average size which can be encountered at any one period. For instance, in the month of November the range in average length (not individual length) is between 11·8 and 22·5 mm.—this from samples of the same year class. This range is almost equal to the increase in average length for the whole period under discussion, namely the second half of August to the first half of January. Although there is this great range in size for any one period, there is a definite and fairly regular increase in the half-monthly average size. In the second half of August the average length of the larvae is 10·70 mm.; in the first half of January it is 22·18 mm. These figures involve results from two different year classes, but inspection of the figure shows that in those instances where observations were made over the same period in different seasons, the half-monthly average length shows such a small variation that it seems justifiable to assume that the rate of growth is approximately the same in different years.

ANOMALOUS LENGTH FREQUENCIES IN ADOLESCENT FORMS

In his reports to the Discovery Committee on the results of the circumpolar cruise, John drew attention to the length grouping of the young krill in the catches obtained. His remarks have been incorporated in the account of the circumpolar cruise on p. 137 below. The larvae from St. 954 fell into two well-defined groups having their maxima at 13 and 18 mm. respectively: this was in September. Later, in October–November, John depicts (Fig. 61) the difference in constitution between krill taken in the Bellingshausen Sea, in the ice-free water near South Georgia and in the Weddell Sea. The two sets of data involve two different problems: (*a*) the occurrence of two distinct length groups simultaneously in the one locality, and (*b*) the occurrence, in different localities at approximately similar times, of young *E. superba* differing widely in length frequency.

There is no obvious explanation for the occurrence of two different length groups in the same locality simultaneously, and the statements made here must be regarded as conjectural.

John's report of this occurrence led to the reconsideration of certain records from 1-m. net catches where groups of *E. superba* had been measured and discarded from the material used in this paper. They were regarded as being outside the range of larval and adolescent lengths here dealt with and were given the provisional designation of "small adults". Thus at St. WS 279, 13. ix. 28, including the "small adults", a bimodal curve was obtained having maxima at 12·37 and 27·4 mm. respectively. There were 163 larvae in the first group and forty-eight in the second, the two groups being separated by 8 mm., from 16 to 24 mm., within which no larvae were found. Again at St. WS 288, 19. ix. 28, the euphausians were arranged in two groups, the one with average length of 13·13 mm. and the other with average length 25·18 mm. There were over 20,000 of the smaller larvae and only thirty-seven of the "small adults"; the two groups were separated by a space of 5·5 mm.

If the three sets of results detailed above from Sts. 954, WS 279 and WS 288 are considered together the peculiar nature of the larger of the two groups is evident. The average growth curve on p. 108 below shows that the average length of the larger group is in each instance much greater than that represented in the graph. Thus in September the normal average is about 12 mm. as opposed to 18 mm. in John's larger group. In October the normal average is about 13 mm. as opposed to 27 and 25 mm. in the "small adults" from Sts. WS 279 and WS 288. Ruud's mean length diagram (1932, p. 41, fig. 8) shows that in October the mean length of adult krill is about 50 mm., so that our "small adults" fall somewhere between the normal adolescent average length and fully adult average length.

The origin of these anomalous forms is not clear, and what the factors are that influence their difference in size is open to speculation. It may be that they are derived from batches of eggs laid very early in the summer season that have pushed ahead with development, obtaining the full benefit of the summer season, whereas the majority of the larvae encountered only obtain benefit from the latter part of the summer, having been derived from eggs laid well on in that season. It may be, as John suggests, that specially favourable environmental conditions, for instance a rich diatom flora, may have been the lot of some of the larvae for a greater period than the remainder. Whatever be the true explanation, the fact that forms occur having this peculiarity of length leads to enquiry as to when they become sexually mature. If the growth rate in these euphausians is similar to that in normal circumstances there is every possibility that they reach a size at which they are sexually mature before the coming of the second winter. If this does occur the complications to be encountered in unravelling the constitution of the adult krill population are greatly increased.

The occurrence of young *E. superba* differing widely in length frequency in different localities at approximately similar times was described by John in a comparison of larvae from the Bellingshausen Sea, from the Weddell Sea ice-edge and from stations in open water west of South Georgia. The period covered was little more than a month and the contrasted results are referred to on p. 141 and shown in Fig. 61. He suggests that better conditions for growth, such as the more abundant diatom flora, may account for the larger size of some of the larvae as compared with the others.

Apart from one instance, mentioned below, no attempt has been made in this paper to correlate the occurrence of diatoms with the krill results. It is regretted that it has not been possible to fulfil the promise implied in Hart's Phytoplankton Report (1934, p. 11). The detailed investigation of this very important field of research will, it is felt, clear up many of the problems connected with the growth and distribution of krill.

The correlation is inserted as it has a bearing on John's suggestion concerning variation in richness of the food supply. In Fig. 28 is shown the average length of adolescent *E. superba* and the abundance of *Thallassiosira antarctica* at the stations indicated. The presence, but not the abundance, of *Chaetoceros socialis* is also represented in the figure; this small colonial form occurred in such great numbers that its abundance could not be estimated satisfactorily. The stations from which the data were taken were all made in the South Georgia plankton survey of November 1930. An account of the phytoplanktonic conditions prevailing is given by Hart (*loc. cit.*, pp. 41 *et seq.*). Concerning *Chaetoceros socialis* he writes (p. 51): "*Chaetoceros socialis*...was taken at fourteen stations only, all of which were grouped towards the southern extremity of the island, some close inshore, and the others in the neighbourhood in which the pack-ice lingered longest during this spring, and all in the water which from the general nature of the phytoplankton as a whole, almost certainly originated in the western Weddell Sea." Concerning *Thallassiosira antarctica* he writes: "It also reached its greatest abundance in the western Weddell Sea surface water round the southern end of the island and was comparatively rare to the north and north-west. It was, however, very widely distributed, being taken at all but six stations on this survey. It occurred in the eastern Weddell Sea water in considerable numbers. The minute form growing in gelatinous colonies which defied estimation was, however, confined to the densely populated region to the south-west with the single exception of the anomalous St. 493 on the Larsen Line." In his summary too he states (p. 64): "The richest and most varied flora was found in the water, mainly of Weddell Sea origin, to the south and south-west of the island. Here the dominant forms were *Chaetoceros socialis*, *Thallassiosira antarctica* and *Chaetoceros neglectus*."

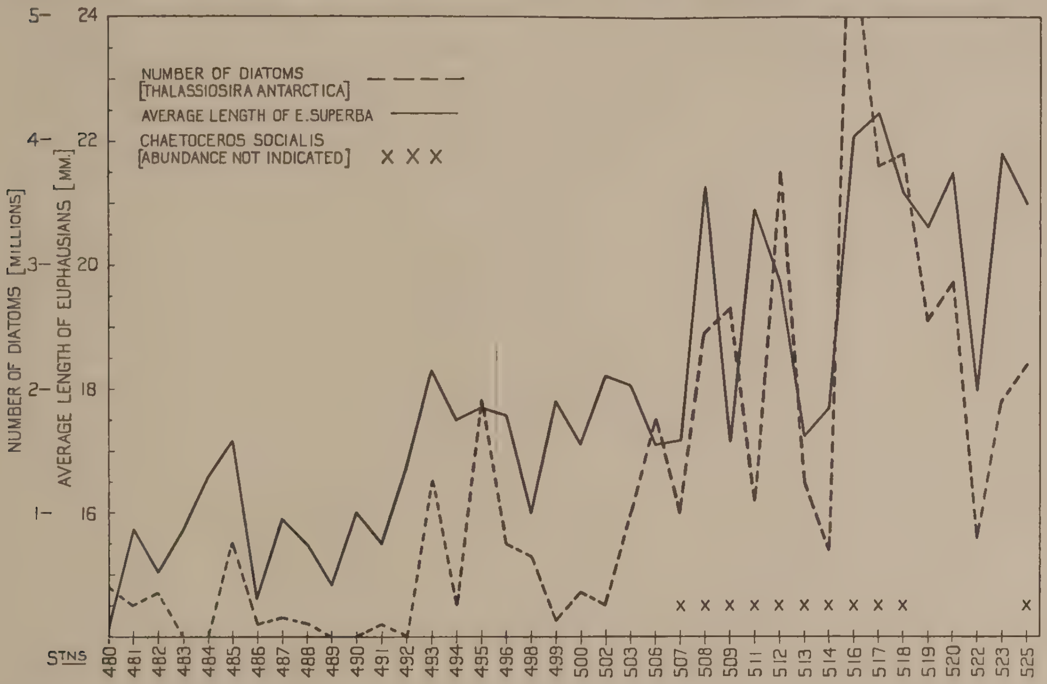

Fig. 28. Diagram showing the relationship between the average length of *Euphausia superba*, the abundance of *Thalassiosira antarctica* and the occurrence of *Chaetoceros socialis*.

Fig. 28 shows that it was at the stations where *Chaetoceros socialis* and *Thallassiosira antarctica* were most abundant that the young krill reached its greatest average length.

On the left of the figure, where *Chaetoceros socialis* is absent and *Thallassiosira antarctica* less abundant, the average size of the krill is small, but on the right, representing stations at the southern end of South Georgia, the average length is greatly increased, and it is here that the two diatoms reach their maximum. It is open to question whether the increase in size of the krill is a direct result of the greater abundance of these particular diatoms, or whether the correlation rests on a community of environmental conditions, namely those to be found in the western Weddell Sea water affecting diatoms in abundance and the euphausian in length.

The results of Hart's examination of the stomach contents of adult and post-larval *Euphausia superba* suggest that the correlation between abundance of *Thallassiosira antarctica* and increased average length of the euphausians is a direct one: for he states that on the occasions when this examination was made, of two forms which occurred constantly, one was *Th. antarctica*.

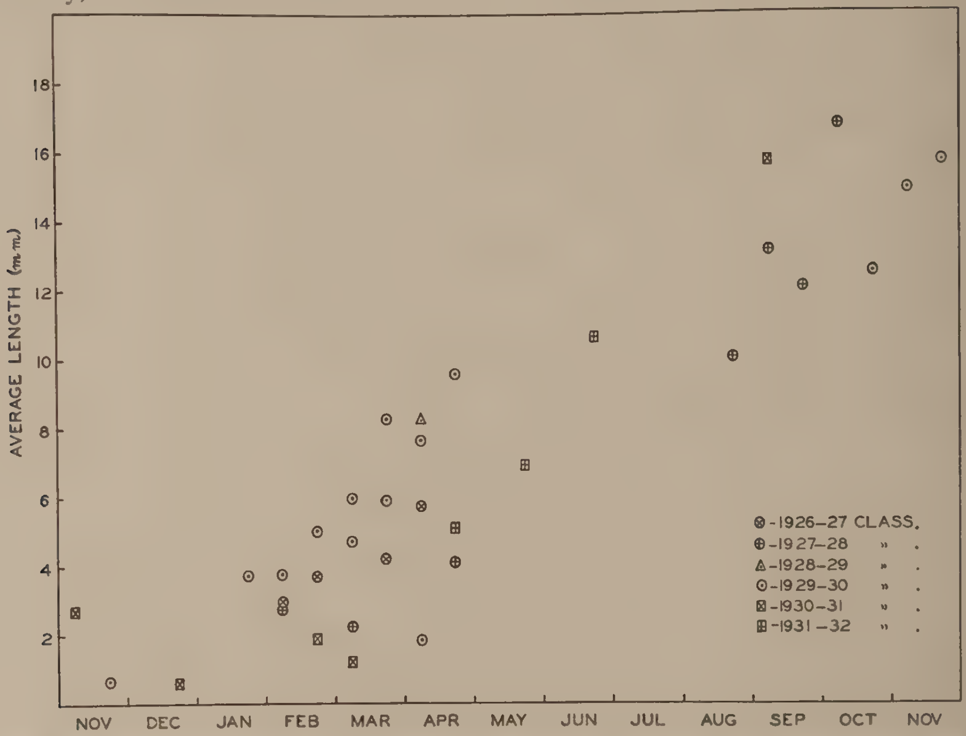

Fig. 29. Half-monthly average length of *Euphausia superba* larvae obtained from 70-cm. vertical nets and from the 1-m. nets fished during the circumpolar cruise.

AVERAGE LENGTH OF LARVAE

In Fig. 29 there is represented the half-monthly average lengths of the *Euphausia superba* larvae obtained from the 70-cm. vertical nets, except for the 1931–2 series which was taken in the 1-m. nets fished during the circumpolar cruise. The scattered distribution of the average lengths gives some indication of the variation which can take place. It is in part due, no doubt, to the different seasons involved and to local environmental dissimilarities which must accelerate or retard the growth rate in accordance with favourable or unfavourable conditions.

Comparison of size with locality of occurrence gave no satisfactory result, nor is there any clear suggestion that larval development periodically commences sooner in one area than another. There is perhaps a hint that in the South Georgia region this may be so, but it is so ill-defined in the data as to be of little importance.

Notwithstanding the great variations in average length which exist at any one time, the figures as a whole show an upward trend from early in the summer season to the end of it, so that by June the larvae have attained an average length of 10·6 mm. The June figure is the only record for that period of the year, but it is from a reasonably large number of measurements and may be considered fairly representative. There is not another record until the second half of August when the length of a small number of larvae in a different season is 10·02 mm. The averages from August onwards are of small numbers of Furcilia 6 and adolescents and for these a better indication of what happens is obtained from the results of the 1-m. net samples set out above.

It may be concluded then that the larvae generally reach a length of about 10 mm. by the time the winter sets in and that this size has been achieved in a period of six months.

AVERAGE GROWTH RATE

Fig. 30 is constructed on the data shown in Figs. 27 and 29 above. It attempts to give some impression of average growth rate during the first year or so of larval life. From November to August the figures represented are the half-monthly average lengths of all the first season larvae taken during that period. From August to January the graph is a repetition of Fig. 27.

The interpretation of the curve of average growth is straightforward in this second portion, but the first part requires some comment. The figure for the first half of November is derived from a single individual. The figures for the second half of December and second half of January are from four and five measurements respectively. In the beginning of January and February numbers have increased to 368 and 112 respectively, and in the second half of February and first half of March they are 1966 and 6602. The next three half-months have roughly comparable figures in the thousands.

The average lengths during this period show no well ordered progression in size. In January and February these figures are very much greater than in the first half of March, where there is a large population with greatly reduced average length. In the second half of March the average length increases again by about 4 mm. The position of the first portion of the average length curve, as shown in the graph, is suggested by these figures. The large number of very small larvae in the first half of March counteracts the effect of the lesser numbers of greater length before and after that time and makes the upward tendency of the growth curve less steep.

It is possible that the conjectured earlier development of larvae in the South Georgia region, referred to in the previous section, is responsible for the differences between the January-February period and March. In the former of the two periods the average lengths are derived, in two of the three half-months, from larvae taken near South Georgia and in the third half-month from the South Shetland-South Sandwich area. The low figure for the first half of March is caused by the great numbers of Metanauplius and 1st Calyptopis taken at stations just north of the South Shetlands in that half-month. But this indefinite division into a north and south area breaks down altogether in the second half of March and first half of April, where the contrasted results of the two periods are both derived from larvae from the Bransfield Strait and South Sandwich Islands-Burdwood Bank Line.

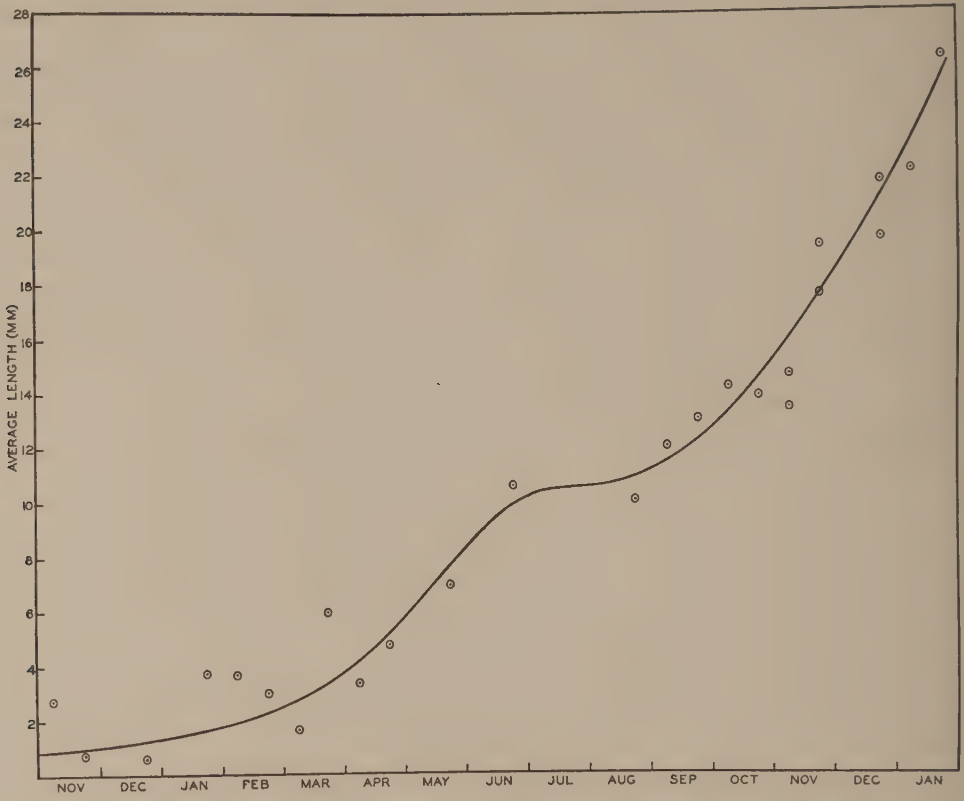

Fig. 30. Graph showing average growth rate of *Euphausia superba* during the first fifteen months of larval life.

The growth curve can be divided into four parts: a low, gently increasing portion from November to March, a steeper portion between March and June, a part having little or no upward tendency between June and August, and a steeply ascending portion from August onwards.

The first part of the curve coincides with the observed period of spawning. The average length of the larval krill population will be kept down by the constant addition of very small developmental forms; it is a period of production and growth. The second part extends from the end of the spawning period to the time when winter conditions become effective. During this period the average length is not affected by influx of very young larvae to the stock—it is exclusively a period of growth. The third division of the graph coincides with the depth of the southern winter when conditions for growth will be unfavourable, and although the June average depends on one sample it may be taken that it represents, roughly at any rate, what actually happens at that time of year. With the coming of spring, environmental conditions become favourable again and growth and development go ahead. The larvae pass from Furcilia 6 to the adolescent phase, so that by the end of the year the former stage of development is no longer encountered in the samples.

This curve of average length corresponds fairly closely with the comparable portion of Ruud's Total Growth Curve (Ruud, 1932, p. 45, fig. 10), but in the present figure the first period referred to above is continued for at least a month longer than Ruud's figure indicates. The period of rapid growth prior to winter covers the period April–June, as compared with February–March depicted in Ruud's figure. This last difference affects the length of the winter period of reduced rate of growth. On the whole, however, the results are in fair agreement, and what differences there are probably originate from the widely separated sources from which the present material was obtained.

The distribution of records throughout the year with the exception of the month of July helps toward a better understanding of the development and growth of this euphausian than was hitherto possible, and although many of the results cannot be regarded as final and conclusive, they at any rate furnish a basis for future corroboration or contradiction.

DISTRIBUTION

EGGS

REGIONAL DISTRIBUTION

In the samples examined there are forty-eight records of eggs from twenty-eight different stations. Most of the catches are of small numbers of eggs, but at one station, St. 540, relatively enormous numbers were obtained, of which the maximum occurred in the 500–250-m. net.

In the Falkland sector, from which all the data relating to eggs have been obtained, they were found in great abundance near Graham Land and the South Shetlands or in the path of currents which have a component towards these places (Fig. 31). They were also found near the South Orkney Islands and South Georgia and above the Scotia Arc in the vicinity of the South Shetlands. They were also found close to the continental shelf west of Graham Land in the south of the Bellingshausen Sea.

The area of greatest abundance of eggs is near the northern end of Graham Land, particularly in the Bransfield Strait; at each group of stations made there between November and February eggs were found in greater or less abundance.

There are probably two main reasons why eggs occur in the regions described. Along the west coast of Graham Land and the Scotia Arc, as far as the South Sandwich Islands at all events, the temperature and salinity are roughly the same (*vide* Deacon, 1933, figs. 12, 13, 24), and these conditions are probably the optimum for eggs to be laid.

These same conditions are continued with small modifications towards the north near South Georgia and the Shag Rocks.

The second reason is probably to be found in the bathymetric conditions. West of Graham Land and in the neighbourhood of the South Shetlands, South Orkneys, South Sandwich, South Georgia and the Shag Rocks there are extensive areas of comparatively shallow water, and on the Scotia Arc joining these regions (*vide* Herdman, 1932, p. 214) the sounding is generally less than 2000 m. If, as will be suggested later, the eggs develop near or at the bottom in comparatively deep water, the depths in these regions are probably most suitable.

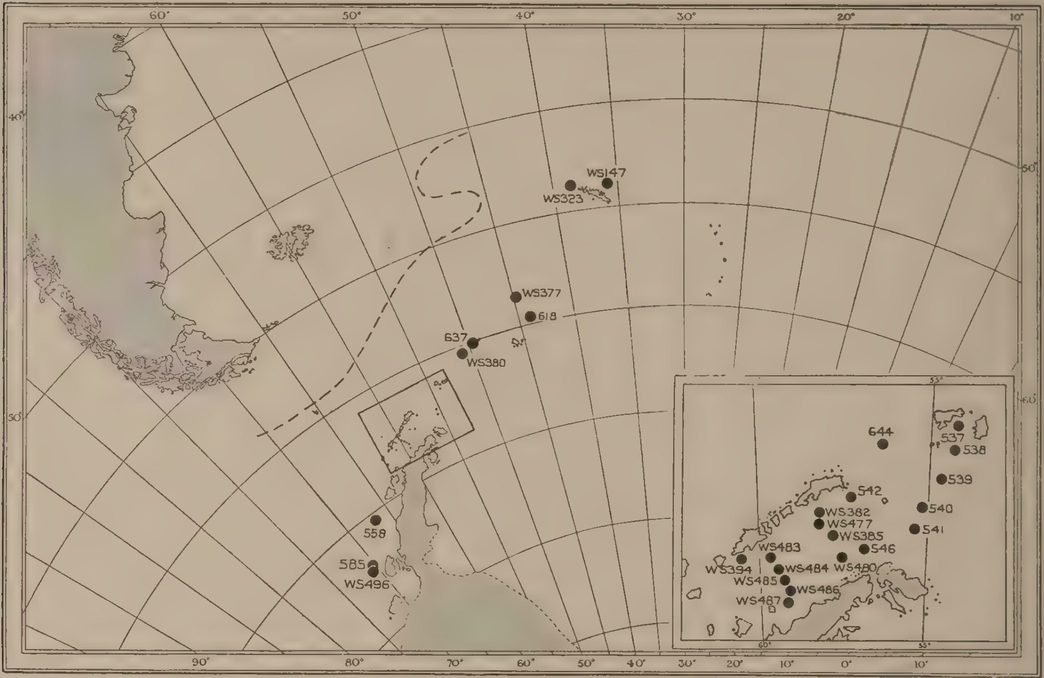
60°
50°
40°
30°
20°
10°
40°
50°
60°
WS147
WS323
WS377
618
637
WS380
558
585
WS496
644
537
538
539
540
541
542
WS382
WS477
WS385
546
WS483
WS394
WS484
WS480
WS485
WS486
WS487
55°
90°
80°
70°
60°
50°
40°
30°
20°
10°
0°
10°

Fig. 31. Distribution of eggs of *Euphausia superba*.

The reason for the particular abundance in the Bransfield Strait area may be that temperature and salinity or the bathymetric conditions are particularly suitable. For, in the Bransfield Strait and separated from the surrounding seas by submarine ridges rising to within 250–600 m. of the surface, there are extensive basins with soundings from 500 to 2000 m. These basins may be particularly favourable for the production and development of eggs. One other striking feature of this region which may make it suitable is the homogeneous condition of the water column. Over the shallow ridges the water is almost completely mixed, and even in the deep basins there are only small changes of temperature and salinity with depth.

The eggs were found in nets fished through water of which the temperature varied from – 1·80 to 2·02° C., but the greater number of catches was in water of temperature less than 0° C., and the greatest numbers of eggs were taken from water of this low temperature.

In salinity the conditions found at St. 540 seem to indicate some approximation to the optimum for the occurrence of eggs. At this station the salinity is between 34·36 and 34·62 parts per thousand, and at others, where the eggs are comparatively plentiful, the salinity corresponds more or less closely to these limits.

VERTICAL DISTRIBUTION

Eggs occurred in all six nets of the vertical series fished from the surface down to 1000 m., but the bulk of them were found below 250 m. At stations where more than one net yielded eggs, and where large numbers were found, the greater proportion was in the lower nets. The depths of the nets in which eggs were found is given in Table III. At all stations a series of closing nets was fished from the surface downwards, but above the shallowest net mentioned no eggs were obtained.

The percentage of the total number of eggs per 50 m. unit in each of the six hauls is as follows:

50– 0 m.	0·8 %
100– 50 m.	8·3 %
250–100 m.	22·0 %
500–250 m.	67·2 %
750–500 m.	1·0 %
1000–750 m.	0·7 %

These percentages are calculated from the total number of eggs in each net haul, corrected to make the numbers comparable. The numbers are very greatly influenced by the great abundance of eggs at St. 540. At this station the sounding was 510 m., so that the deepest net fished reached to 10 m. from the sea-bottom. It suggests a concentration of eggs near the bottom and a possible explanation of their relative paucity in our catches as a whole.

If the eggs are laid at or near the bottom, their occurrence in the surface nets might easily be accounted for by surface mixing of the water column, which in the Bransfield Strait region is known to be particularly effective.

Rustad (1930) referring to *Thysanoessa macrura* suggested that spawning in that species might take place below 400 m., and that eggs and sexually mature animals might be concentrated in circumscribed shoals. He thought it unlikely, however, that "a surface form like *Euphausia superba* would spawn in deep water". Ruud (1932) discounted the explanation of circumscribed shoals and, referring to *E. superba*, postulated the hypothesis that it spawns close to, or right under, the drifting ice. In a later paper Rustad (1934, p. 36) replies to Ruud's criticism and states "that the physical conditions in the deeper layers, as compared with those right under the ice should be unfavourable to the spawning and development of the youngest larvae, is hard to see. The chief difference is found in the salinity but this seems to be of less importance, our finds demonstrating that the larvae may develop at the higher salinity in the deeper layers; nor does the smaller content of oxygen seem to be unfavourable."

Rustad admits that he has not sufficient material to get a trustworthy idea of the distribution of the eggs and points out the limitations due to making only two vertical net hauls—the lower from 400 m.—in the interpretation of his results.

If eggs of *E. superba* occur in abundance in the proximity of drifting ice, it is rather surprising that so very few have been taken over a period of four years in the surface nets at stations made by the vessels of the Discovery Committee at the edge of, or actually in, pack-ice. Many of these stations were made at a time of year when *E. superba* is known to spawn, and if the number of eggs at St. 540, for instance, is typical of a spawning region the eggs could not fail to have been conspicuous in the plankton of the surface nets.

From discussion with Dr T. J. Hart it is learned that in his examination of the samples analysed for his Phytoplankton Report (Hart, 1934) he did not find any eggs recognizable as belonging to *E. superba*. The samples were from 50-cm. vertical nets (N 50 V) fished from 100 m. to surface, and, as the Report effectually demonstrates, used very frequently and over a wide area in the Antarctic. This indication of distribution of eggs in other than the first hundred metres, although admittedly negative, is based on such a large number of observations that it cannot be neglected.

Evidence in favour of deep spawning, additional to that supplied by the vertical distribution of the eggs themselves, is the occasional occurrence of fully adult animals in the deep hauls of the 70-cm. vertical nets. It should be emphasized that this net, like others, is selective in its fishing, and it is unusual to find adults of *E. superba* in it at any time. That they should be found deep down at the same time as eggs are taken, as indicated in Table III, leads one to infer that their occurrence at these depths is connected with spawning. Their condition as regards maturity also indicates that departure from the surface is associated with the deposition of eggs. The capture, referred to on p. 17, of ninety-five adults including many gravid females in a 250–100 m. haul lends still further support to the hypothesis of deep spawning in this species, and the fact that they were the only adults to be taken in any of the vertical or oblique nets hauled at this station is in favour of Rustad's idea that the animals congregate in circumscribed shoals for spawning.

It is remarkable that comparatively few eggs have been found in the samples analysed, and although Rustad's suggestion of circumscribed shoaling "and the consequent concentration of the eggs in relatively small areas" may be partly the reason I do not think that it is completely satisfactory. *E. superba* must be reproduced in immense numbers to hold the key position it has in the ecology of Antarctic life. The yield of the 70-cm. vertical nets, with the possible exception of those at St. 540, is surely not indicative of the normal concentration.

Is it possible that the development of eggs of *E. superba* takes place in water which is deeper than the lower limit of the vertical nets and that the eggs obtained are the scattered product of dispersal of a much greater mass situated in still deeper water? It may be that in this species the eggs, when laid, usually sink below 1000 m., and that the great abundance at St. 540 is due to the net coming within 10 m. of the sea-bottom at a place of concentration where eggs are in somewhat shallower water than is usual.

Much more positive evidence is required on this problem before any definite solution can be put forward; conclusions drawn purely from negative evidence or from outstanding exceptions to the normal are very apt to be misleading, if not altogether wrong.

TIME OF SPAWNING

It is possible to get information about the duration of spawning in at least two ways. The first by observation of adults for indication of sexual maturity, and the other by consideration of the records of eggs in the plankton. It is not proposed in the present paper to deal with the first method beyond referring to the spawning of females in aquaria on the ship. The earliest record of this is on December 21 in the season 1930–1, and it is followed by another almost a month later on January 19. The latest record of eggs hatching is on February 10 in the season 1929–30. There is, then, from this source evidence of spawning taking place over about seven weeks at the height of the southern summer.

Conclusions based on the presence of eggs in the plankton involve the assumption that the time between the laying of eggs and the development into Naupliar and Calyptopis forms is very brief. The occurrence of all stages of development up to the clearly distinguishable 1st Nauplius in eggs in one catch, and the fewness of 1st and 2nd Nauplii in any of the catches, suggest that this is probably the case. Table XXXIX shows in half-monthly periods for the years 1928–31 the time at which eggs were found.

Table XXXIX. *Showing the half-monthly periods in which eggs have been found*

Season	1927–8	1928–9	1929–30	1930–1
Nov. 1–15	—	—	X	—
16–30	—	—	X	—
Dec. 1–15	—	—	—	—
16–31	—	X	X	X
Jan. 1–15	—	—	—	X
16–31	—	—	—	—
Feb. 1–14	—	X	X	—
15–28	X	X	—	X
Mar. 1–15	—	—	—	X

In the season 1927–8 there were no observations before February, but from the latter half of this month there is one record of eggs. In the season 1928–9 eggs were found between the second half of December and the second half of February, in the 1929–30 season between the first half of November and the first half of February and in the 1930–1 season between the second half of December and the first half of March. The longest period of spawning in one season is three and a half months, and for all the seasons under consideration the range is four and a half months. In the 1930–1 season the station from which the first eggs were recorded was not more than 120 miles distant from the station nearly three months later at which the last eggs were found, so that the extended egg-laying period cannot be attributed to great difference in the locality from which the plankton samples were taken. In *E. superba*, therefore, it may be concluded from the available evidence that spawning is not restricted to one short period but is diffused over most of the months of the southern summer. There are indications that the greatest production of eggs is in November–December, but as regards abundance a distorted impression is obtained because certain plankton stations were taken at times and places close to each other while others were in these respects spaced widely apart.

NAUPLII

It is not possible to come to any definite conclusion regarding distribution of Nauplii when dealing with such small numbers as were found in our plankton samples. Both 1st and 2nd Nauplii were taken only at stations from which eggs were also recorded, so that the general remarks regarding the regional distribution of eggs apply equally to the Nauplii.

Both the 1st Nauplii were found below 100 m., the one in the 250–100-m. net and the other in the 750–500-m. net. It may be noted, too, that both Ruud's records are from nets fishing in subsurface water.

At three stations the 2nd Nauplii were in the 250–100-m. net, at three in the 500–250-m. net, and the remaining one was in the 750–500-m. net. There is no record from above 100 m. At two of the three stations where the Nauplii occurred in the 250–100-m. net eggs were found in the shallower nets, and it is possible that the Nauplii developed from such eggs.

As mentioned above, the rarity of 1st and 2nd Nauplii and the smallness of the number where records exist may indicate that these stages are passed through very rapidly in this species, as in other euphausiids where the development is known (*vide* Lebour, 1926 *c*, pp. 520, 521).

In the 1929–30 season all the 2nd Nauplii were taken in the second half of November, and in the 1930–1 season in the latter part of December. They were not found outside the range of the spawning period.

METANAUPLIUS

REGIONAL DISTRIBUTION

The distribution of the bulk of the Metanauplii differs in a marked manner from that of the eggs. The latter were concentrated within the Bransfield Strait, but, with the exception of those taken at St. 639, all the Metanauplii were taken north of the ridge formed by the Scotia Arc, and the exception accounts for two only out of a recorded total of over 4000 of this stage. Within the area of their distribution in the Scotia Sea this stage is found in the north-east at St. WS 197, not far distant from South Georgia. At this station 115 Metanauplii were taken between 1000 and 750 m. In the north-west they were found as far north of the South Shetlands as the vicinity of the Antarctic convergence (St. 646) from surface down to 500 m. to the number of fifty-six. The greatest concentration of larvae was at St. 647, the one before that just mentioned; here 4279 Metanauplii were taken. The distribution of the stations where Metanauplii were taken is shown in Fig. 32.

VERTICAL DISTRIBUTION

The majority of the larvae belonging to this stage were found in the two deepest nets between 500 and 1000 m., although their occurrence is recorded also in the four upper nets at certain stations. At St. 647, where the larvae occurred in greater abundance than at all the other stations added together, they are entirely confined to depths between 500 and 1000 m. In areas of open water away from the influence of the ridge of the Scotia Arc, and, in the case of St. 648, away from the influence of the Antarctic convergence, the larvae are entirely restricted to depths below 500 m. It is at such depths that the bulk of Metanauplii are found, and it is important to consider the conditions of their environment.

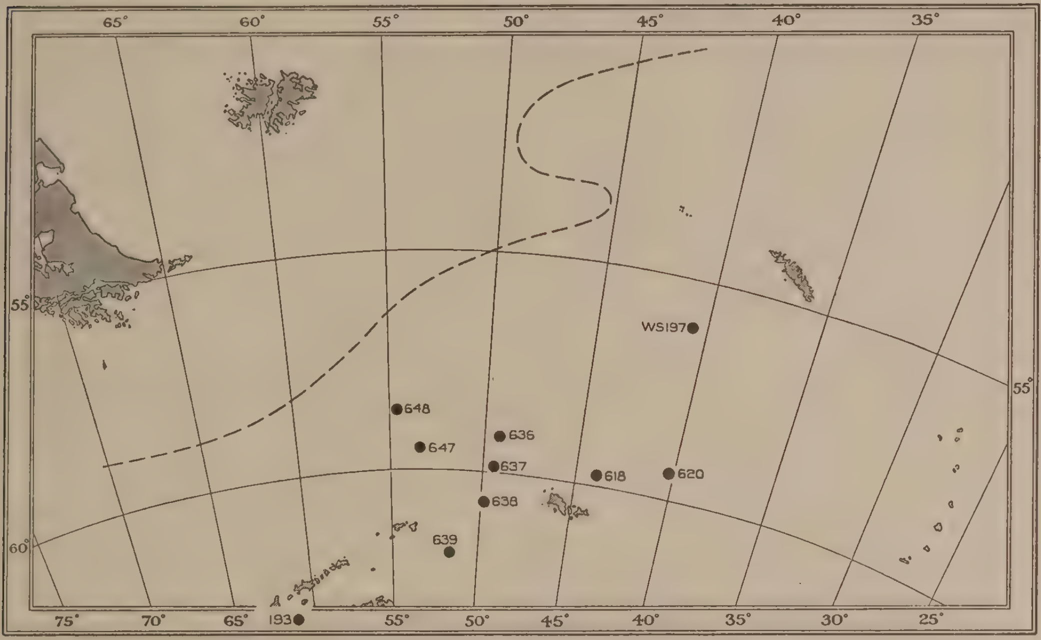

Fig. 32. Distribution of Metanauplius of *Euphausia superba*.

They are found in the warm deep water and not in cold Antarctic surface water. The properties of this warm deep-water layer are described by Deacon (1933, pp. 222 *et seq.*), and it is not necessary to recapitulate them here beyond pointing out that he states that the depth of the maximum temperature in 57° 30′ S is 600 m. and of maximum salinity 700 m., and that the usual component of movement is from warm to cold regions and not from cold to warm.

Now if the temperature range within which Metanauplii were taken is examined, it will be seen that although the larvae are occasionally found in water of temperature below 0° C. they apparently favour the warmer water. Thus at St. 647 the range is between 1·34 and 2·01° C., at St. WS 197 it is 1·33–1·27° C., and with like positive temperatures for Sts. 618, 620, 636, 637 and 648. With regard to the last station, at which the larvae were found in each of the four nets from surface down to 500 m., it may be that the warm surface temperature, due to the proximity of the station to the convergence, produced the same favourable conditions for spawning and subsequent development as are more generally to be sought for in the warm deep layer below 250 m.

The significance of the vertical distribution of the Metanauplii is considered in conjunction with that of later larval forms on p. 163.

Later stages of development were present at all the stations where Metanauplii occurred, and it is interesting to compare their vertical distribution with that of the Metanauplii. In this comparison Sts. 639 and 648 have been regarded as exceptional and the distribution of the larvae taken there is not represented in Fig. 33. At the former station two Metanauplii were found, both in the surface net, and at the latter this stage was present from the surface down to 500 m., with greatest concentration between 100–50 m. In the remaining seven stations, as shown in Fig. 33, the Metanauplii are concentrated in the lowest nets fished. With the exception of two individuals all are in the 750–500 m. and 1000–750 m. nets. It will be seen that there is considerable variation in the vertical distribution of the older larvae and that this can be connected with the time of day at which the net hauls were made. The stations have been arranged in a sequence from midday to midday, the first starting at 1907 and the last finishing just after midday. The figure shows that in the larvae of *E. superba* subsequent to the Metanauplius stage there is a definite diurnal migration, so that during the hours of darkness they are concentrated between the surface and 100 m., whereas at other times they are massed at 500–250 m. The vertical migration of larvae will be referred to more fully later; it is sufficient here to mark the contrast between the behaviour of the Metanauplius and subsequent larval stages.

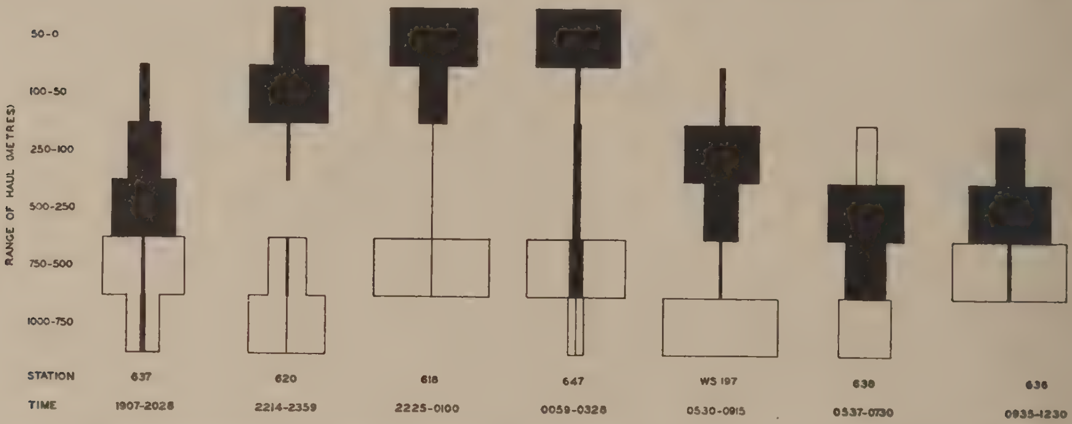

Fig. 33. Diagram showing the vertical distribution of the Metanauplius and later stages of development at the stations indicated. Areas shown in outline represent the Metanauplius, areas in black represent later stages.

Ruud (1932, p. 33) says: "We only find larvae in any quantities in our samples at the stage when they begin to feed, i.e. the first Calyptopis stage (Taube, 1915). The younger larvae would naturally be found with the eggs." With respect to the last statement the present observations on the vertical distribution of the Metanauplius furnish very favourable evidence for the hypothesis that the eggs are to be found in deep water rather than at the surface.

TIME OF OCCURRENCE

All the Metanauplii were taken during the months of February, March and April and, while it is possible that about the middle of April may be the latest time for the occurrence of this form, the range in the other direction must be extended considerably beyond the date of the earliest record. It will be seen presently that there is an isolated record of a 2nd Calyptopis in the first half of November, which would indicate a period for the production of Metanauplii prolonged to at least five and a half months. But if this 2nd Calyptopis be regarded as an unusual exception—and that this may be so is indicated by there being no record of 2nd Calyptopis again until two and a half months later—then the normal time of occurrence of Metanauplii may be reduced to a period of about three months, extending from mid-January to mid-April in the second half of the southern summer.

CALYPTOPIS STAGES, FURCILIA STAGES AND ADOLESCENTS

REGIONAL DISTRIBUTION

It has been mentioned in the Introduction to this paper that the 70-cm. vertical nets yielded the main supply of earlier developmental forms and the 1-m. nets older larvae and adolescents. In discussing the distribution of stages subsequent to the Metanauplius it is convenient to classify the material examined in three divisions as follows:

Material caught in the 70-cm. nets.
Material obtained during the circumpolar cruise.
Material caught in the 1-m. nets.

Of these three divisions the first is concerned mainly with first season larvae, that is to say larvae taken during the summer season in which they were hatched; and the third division deals with second season forms, including late Furcilia and adolescents, hatched in the summer previous to that in which they were caught. The circumpolar cruise was made chiefly in the winter months and only material from the 1-m. nets was examined. As regards both time of year and state of development the larvae in the second of the above sections are placed intermediately between those of the other two sections.

MATERIAL CAUGHT IN THE 70-CM. NETS

In the discussion of the 70-cm. net catches the stations have been divided into the following areas:

(1) Falkland Islands to South Georgia.
(2) South Georgia surveys.

(3) South Georgia to South Sandwich Islands.
(4) Scotia Sea.
(5) Drake Strait.
(6) Bransfield Strait surveys.
(7) Palmer Archipelago and Bellingshausen Sea.
(8) East of South Georgia (ice-edge stations).
(9) Weddell Sea.

For each area the groups of observations have been arranged with reference to the southern summer according to the time of year during which they were made and not in strict chronological order.

(1) Falkland Islands to South Georgia

	Stations	Year	Time of year
(*a*)	WS 251–256	1928	August
(*b*)	WS 314–320	1928	December
(*c*)	WS 137–143	1928	February
(*d*)	WS 518–526	1930	February–March
(*e*)	655–659	1931	March
(*f*)	WS 427–433	1929	April–May

(*a*) August 1928 (Sts. WS 251–256). Fig. 34.*

Only one larva was recorded at St. WS 255, west of the Shag Rocks: it was a Furcilia 6.

(*b*) December 1928 (Sts. WS 314–320). Fig. 35.

No larvae were taken.

(*c*) February 1928 (Sts. WS 137–143). Fig. 36.

The first three stations were made in sub-Antarctic water; at the last of these, St. WS 139, four Calyptopis were found in the 500–250 m. net in temperatures of 2·66–3·09° C. At the surface at this station the temperature was 6·15° C. The larvae were carefully examined as it was considered unusual to get *E. superba* to the north of the Antarctic convergence, but they were undoubtedly this species. One Calyptopis 1 and one Calyptopis 2 were found at St. WS 141, 250–100 m., and one Calyptopis 3 at 500–250 m.

(*d*) and (*e*) February–March 1930 and March 1931 (Sts. WS 518–526 and 655–659). Figs. 37 and 38.

No *E. superba*.

(*f*) April–May 1929 (Sts. WS 427–433). Fig. 39.

Larvae were taken at the first station only, situated between the north-west end of South Georgia and the Shag Rocks, and then only in small numbers, five in all representing Furcilia 3, 4 and 5.

In the Falkland Islands-South Georgia region larvae occur, but in small quantity, from the Antarctic convergence eastwards to South Georgia. A late Furcilia was obtained early in the season and Calyptopis and early Furcilia after the new year in the second half of the southern summer.

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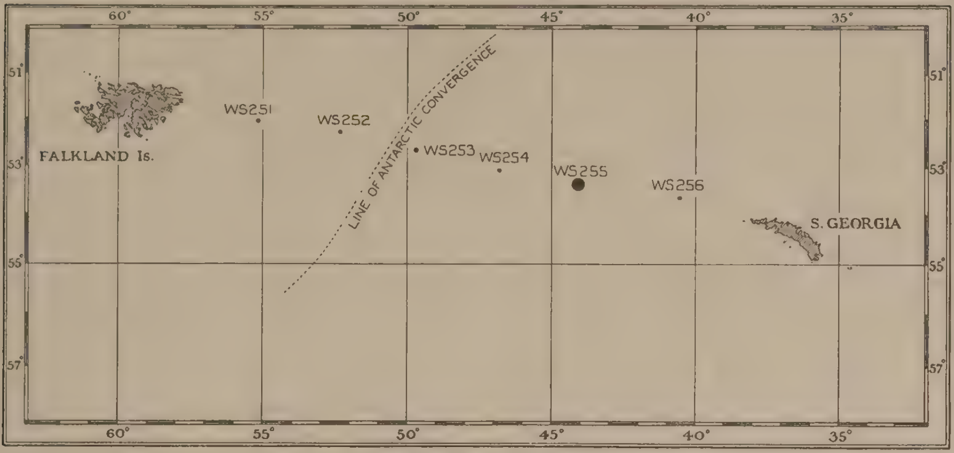
* In this and in the subsequent distribution charts the larger circular marks indicate stations at which krill was found. The smaller marks indicate stations where the nets under consideration were examined with negative results.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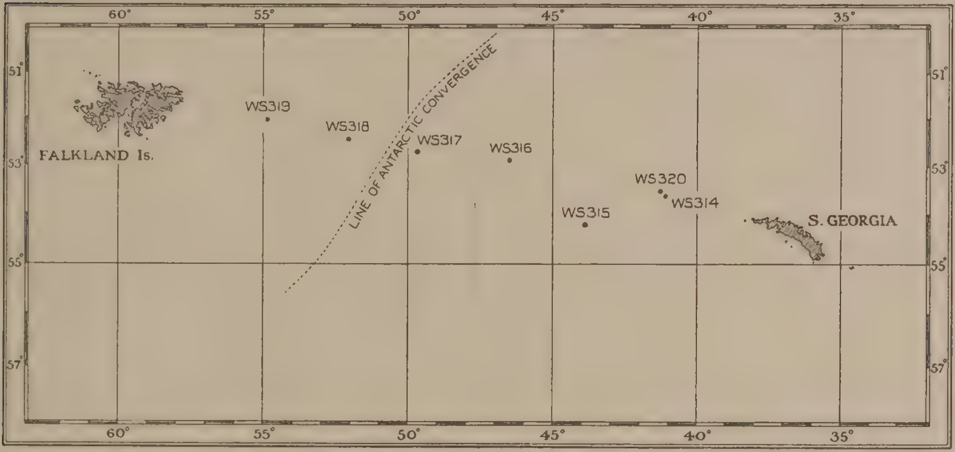
WS256
LINE OF ANTARCTIC CONVERGENCE
S. GEORGIA

Fig. 34. Distribution of young *Euphausia superba* between Falkland Islands and South Georgia (70-cm. net hauls), August 1928.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WS315
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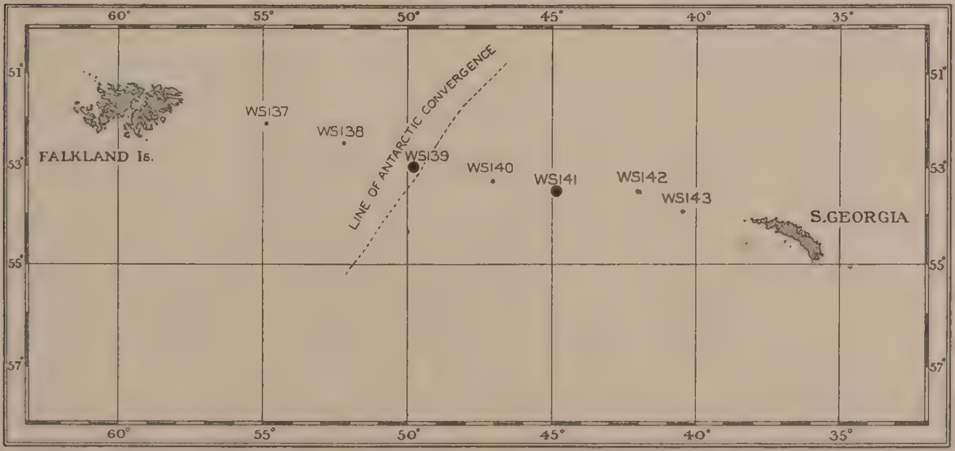
S. GEORGIA

Fig. 35. Distribution of young *Euphausia superba* between Falkland Islands and South Georgia (70-cm. net hauls), December 1928.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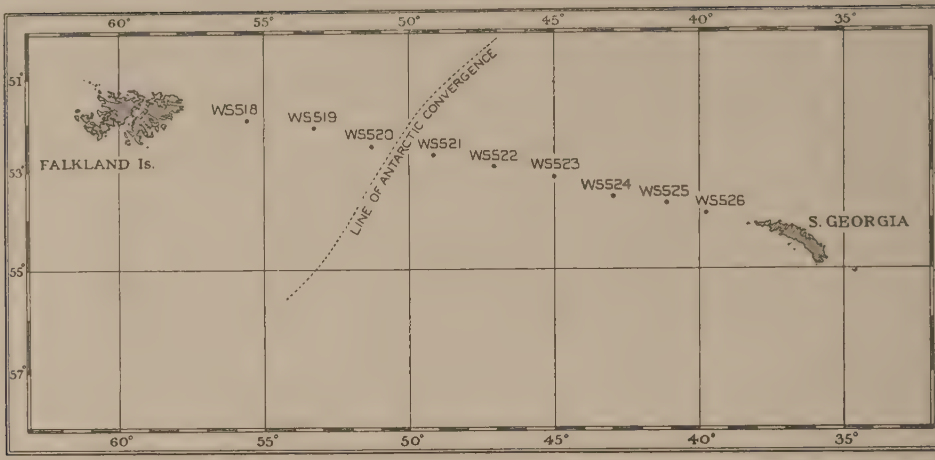
WS143
LINE OF ANTARCTIC CONVERGENCE
S.GEORGIA

Fig. 36. Distribution of young *Euphausia superba* between Falkland Islands and South Georgia (70-cm. net hauls), February 1928.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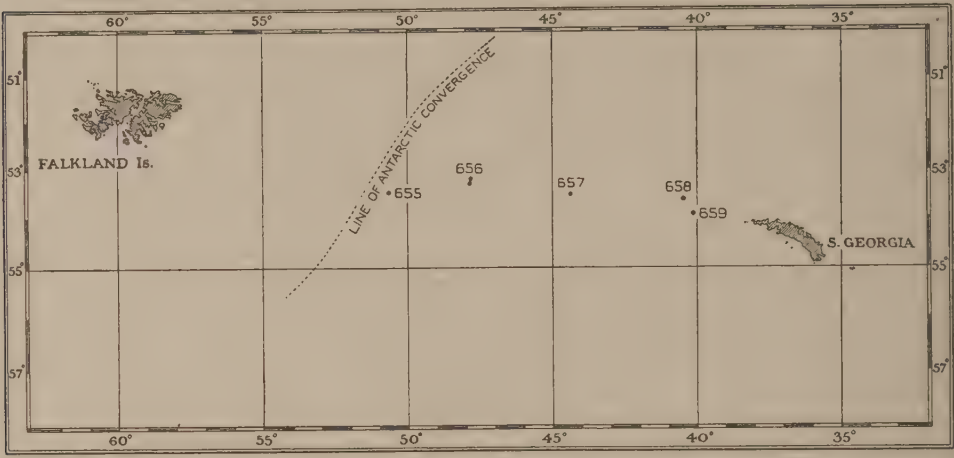
LINE OF ANTARCTIC CONVERGENCE

Fig. 37. Distribution of young *Euphausia superba* between Falkland Islands and South Georgia (70-cm. net hauls), February–March 1930.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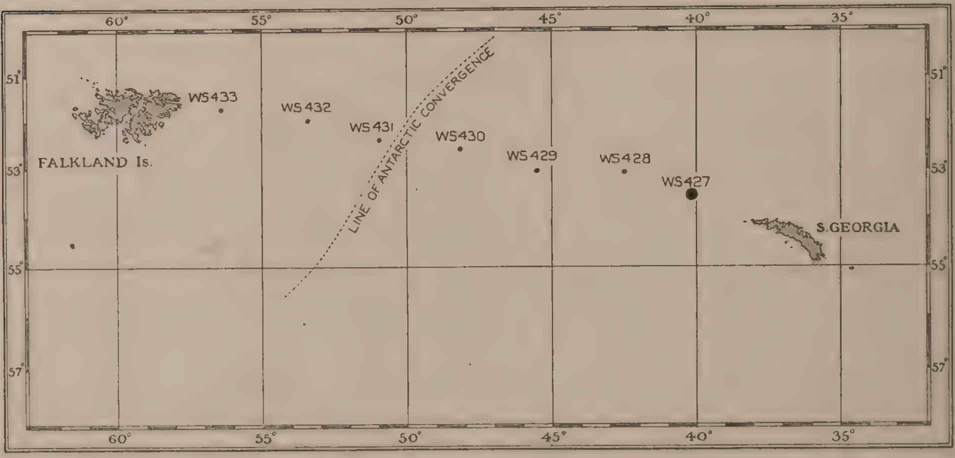
LINE OF ANTARCTIC CONVERGENCE

Fig. 38. Distribution of young *Euphausia superba* between Falkland Islands and South Georgia (70-cm. net hauls), March 1931.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LINE OF ANTARCTIC CONVERGENCE

Fig. 39. Distribution of young *Euphausia superba* between Falkland Islands and South Georgia (70-cm. net hauls), April–May 1929.

(2) South Georgia surveys

	Stations	Year	Time of year
(*a*)	WS 257–296	1928	August–September–October
(*b*)	475–525	1930	November–December
(*c*)	WS 321–365	1928–9	December–January
(*d*)	300–358	1930	January–February
(*e*)	WS 144–195	1928	February–March
(*f*)	WS 567–575	1931	March
(*g*)	WS 417–426	1929	April
(*h*)	393	1930	May

(*a*) Survey of August–September–October 1928 (Sts. WS 257–296). Fig. 40.

As shown in Fig. 40 krill was present at several stations in this survey. All the larvae belonged to the previous year class and with the exception of one adolescent at St. WS 282 and WS 295 all were in the Furcilia 6 stage. The number of larvae recorded is remarkably small, never more than three at any one station.

(*b*) Survey of November–December 1930 (Sts. 475–525). Fig. 41.

With the exception of one Calyptopis 3 at St. 477 all the young krill from this survey belonged to the previous year class and were either Furcilia 6 or small adolescents. As in the previous survey the number of larvae recorded is very small except at the innermost station near Bird Island where 169 were found. The 1-m. net hauls, however, give a better indication of the abundance of the later and larger developmental forms. The majority of the records are confined to the two uppermost nets, but it is interesting to note that there are two from 1000–750 m. net hauls. The larvae do not show any indication of restriction to the areas beyond the shallow coastal water, and the largest number taken was close inshore. It is likely that this distribution is intimately bound up with the presence of pack-ice in the vicinity of South Georgia during this survey and just before it was made. The predilection of adolescents for the vicinity of pack-ice will be demonstrated later; it is mentioned here to give a possible explanation of larvae so close inshore.

(*c*) Survey of December–January 1928–9 (Sts. WS 321–365). Fig. 42.

No larvae were caught during this survey. The only evidence of the presence of *E. superba* was one egg taken at St. WS 323, the first deep-water station near Bird Island.

(*d*) Survey of January–February 1930 (Sts. 300–358). Fig. 43.

The stations at which larvae were obtained are shown in Fig. 43. To demonstrate that practically all the larvae were taken at stations made in deep water the 250-m. contour has been inserted in the map.

The larval stages found were Calyptopis 1, 2 and 3 and Furcilia 1, 2 and 3, with Calyptopis 3 predominating. At one station (St. 356) gravid females were taken in the 250–100 m. net, but neither eggs nor stages younger than Calyptopis 2 were found in the plankton samples.

The larvae were fairly abundant in number with the maximum at St. 303, where 133 were taken. Ninety-nine were taken at St. 320, four other stations had more than twenty larvae, and eighteen stations had less than ten.

At one station or another where the young euphausians were taken the net hauls from surface down to 1000 m. yielded larvae, and although the 500–250 m. net appears to be the deep limit for the majority it is not so for all of them. There is no reason to suppose that the larvae from the deeper nets were dead specimens sinking to the sea-bottom, as it is easy to distinguish dead *E. superba* in the samples.

The occurrence of the larvae at stations made in water deeper than 250 m., as opposed to shallower water stations, may be connected with their vertical distribution. It has already been remarked

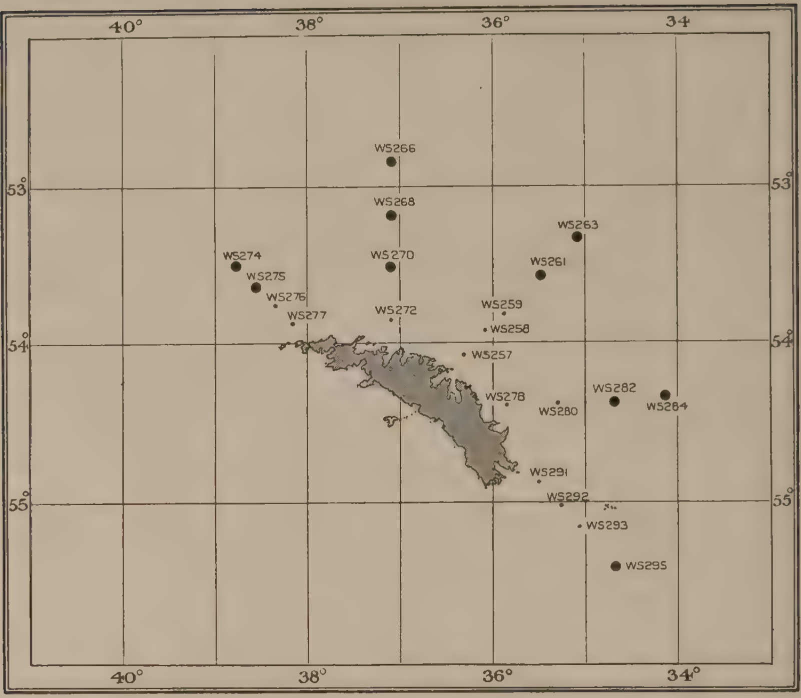
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Fig. 40. Distribution of young *Euphausia superba*, South Georgia survey (70-cm. net hauls), August–October 1928.

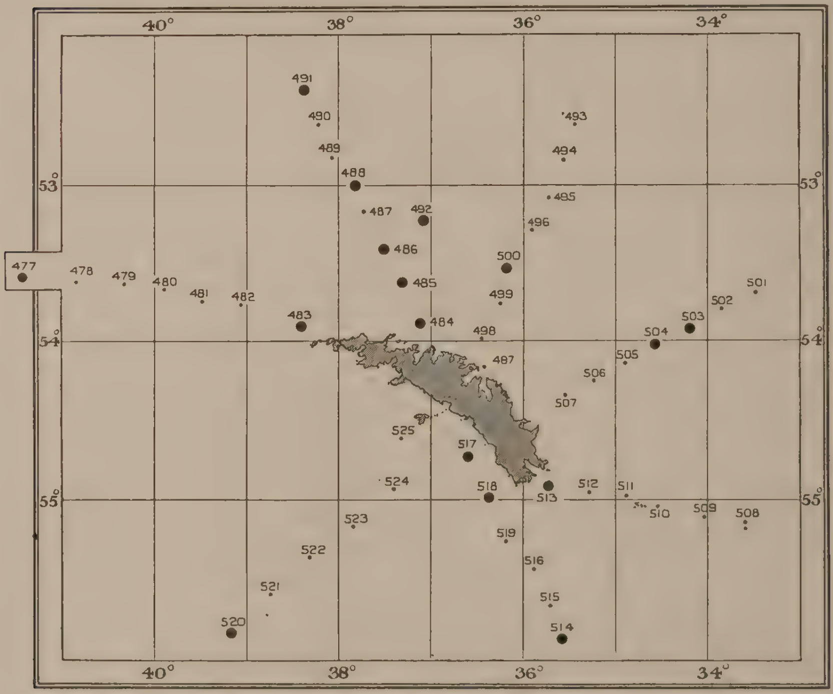
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Fig. 41. Distribution of young *Euphausia superba*, South Georgia survey (70-cm. net hauls), November–December 1930.

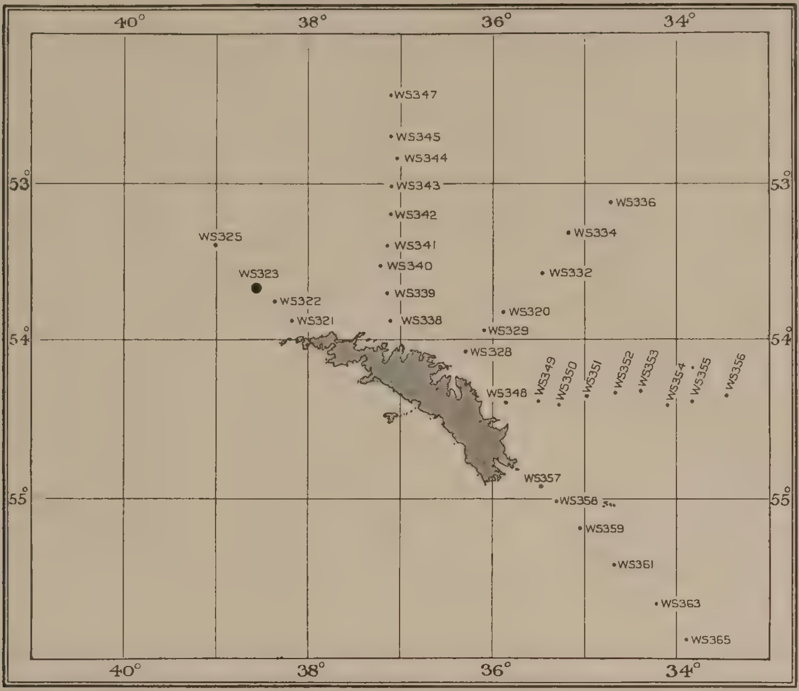
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Fig. 42. Distribution of young *Euphausia superba*, South Georgia survey (70-cm. net hauls), December–January 1928–9

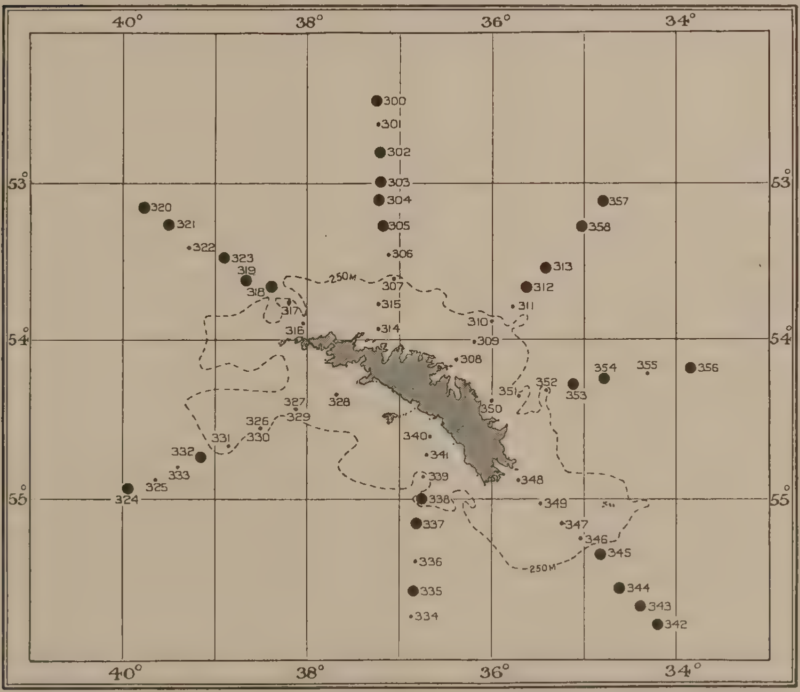
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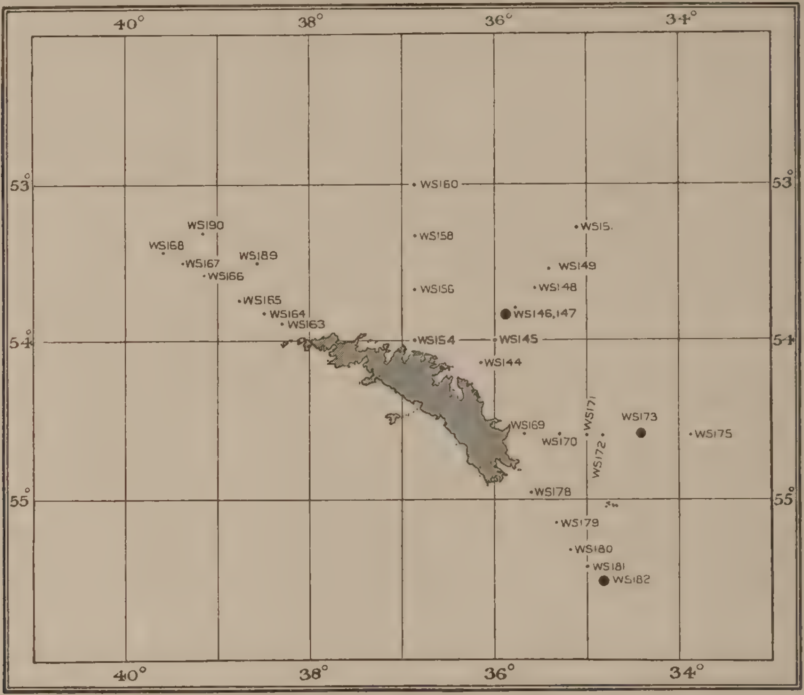
Fig. 43. Distribution of young *Euphausia superba*, South Georgia survey (70-cm. net hauls), January–February 1930.

(p. 115) that the larvae later in development than the Metanauplius, undergo a vertical migration diurnally through a column of water greater in depth than 250 m. That they should be absent from water shallower than 250 m. in this survey argues that for reasons connected with light intensity it is essential for them to have greater depths to recede to in the daytime. This will be dealt with in the section on vertical migration.

(*e*) Survey of February–March 1928 (Sts. WS 144–195). Fig. 44.

Very few larvae were taken during this survey; one Calyptopis 2 at St. WS 173 just beyond the shallow water on the Vakop Line and two Calyptopis 1 and 2 at St. WS 182 in the first deep-water station on the Clarke Rocks Line. It was noted above that one egg was taken at St. WS 147 in the 250–100 m. net. This station was on the edge of the continental shelf with a sounding of 274 m., but the previous station (WS 146), taken in almost the same position three days before, gave a sounding of 1096 m., so that both must have been on the very edge of the continental shelf.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WS182

Fig. 44. Distribution of young *Euphausia superba*, South Georgia survey (70-cm. net hauls), February–March 1928.

(*f*) Prince Olaf lines, March 1931 (Sts. WS 567–575). Fig. 45.

Two lines of stations to the northward from Prince Olaf Harbour were made in March 1931, and at two stations, both in deep water, one Calyptopis 1 and one Furcilia 6 were recorded.

(*g*) South-west side of South Georgia, April 1929 (Sts. WS 417–426). Fig. 46.

No larvae were taken at any of the stations.

(*h*) East side of South Georgia, May 1930 (St. 393).

At this station four flights of nets, each from 300 m. to the surface, were made, but only one larva, a Furcilia 5, was taken.

Two points are made apparent by these surveys; first that Calyptopis and early

Furcilia stages are to be found chiefly in offshore deeper water, and secondly that older larvae, Furcilia 6 and adolescents, are not so restricted but come close to the island. It should be noted, too, that there is an ordered arrangement in the occurrence of the larvae. Up to the end of the year, that is until about the middle of the summer season, only larvae and adolescents of the previous year class are obtained. In the new year Calyptopis and early Furcilia appear, indicating that spawning must commence about the end of the year. From March onwards later Furcilia are obtained but with Calyptopis 1 still occurring.

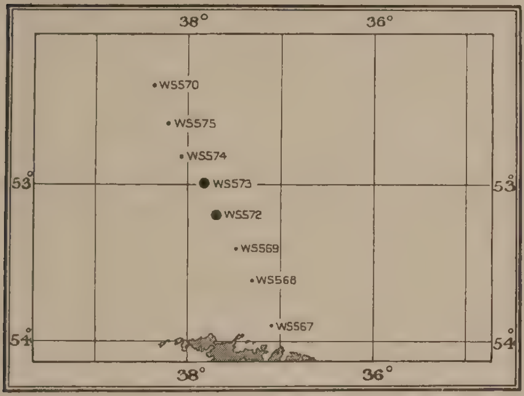

Fig. 45. Distribution of young *Euphausia superba*, Prince Olaf lines (70-cm. net hauls), March 1931.

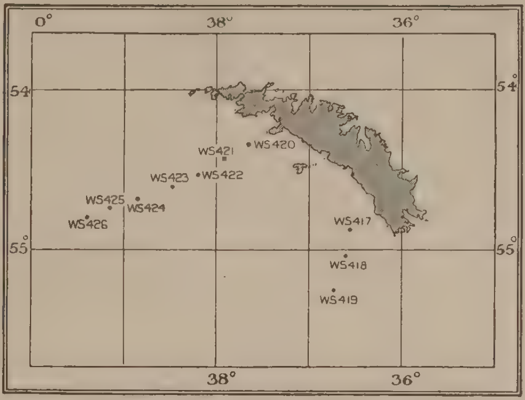

Fig. 46. Distribution of young *Euphausia superba*, south-west side of South Georgia (70-cm. net hauls), April 1929.

(3) South Georgia to the South Sandwich Islands, February–March 1930 (Sts. 360–369). Fig. 47

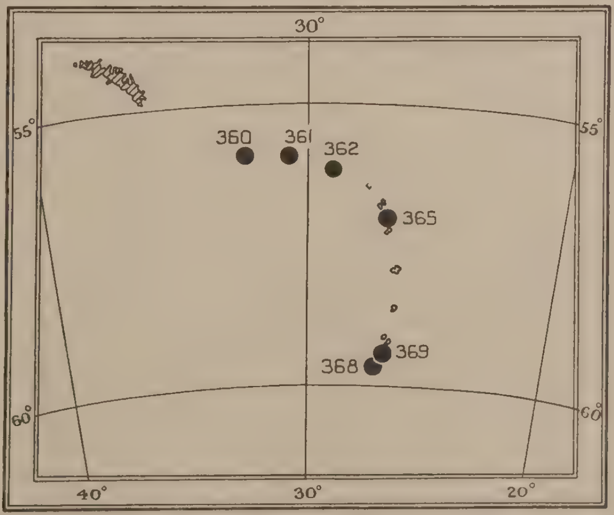

Fig. 47. Distribution of young *Euphausia superba*, South Georgia to South Sandwich Islands (70-cm. net hauls), February–March 1930.

The line of stations from South Georgia to the South Sandwich Islands was made immediately after the completion of the South Georgia survey of January–February 1930 described above. It will be recalled that more larvae were taken during this survey than in any of the others carried out in that neighbourhood. This abundance was increased at the stations of the South Sandwich line. Larvae were taken at each of the six stations where the 70-cm. vertical nets were fished, and at most of these the numbers were greatly in excess of those in the net hauls of the above-mentioned South Georgia survey.

Sts. 360, 361 and 362 were made between South Georgia and the northernmost of the South Sandwich Group. At St. 360 one each of Calyptopis 3 and Furcilia 1, 2, 3 and 6 were taken; at

St. 361 there were 339 larvae with Furcilia 1 predominating but with Calyptopis 2 and 3 and Furcilia 3 and 4 also present, and at St 362 there were 343 larvae, with Calyptopis 3 predominating but having in addition Calyptopis 2 and Furcilia 1, 2 and 3. All these stations were in water over 3000 m. deep, but all were in the vicinity of the ridge connecting South Georgia and the South Sandwich Islands.

St. 365 was situated between Visokoi and Candlemas Island. 601 larvae were taken there with Calyptopis 3 predominating. Calyptopis 1 and 2 and Furcilia 1 and 2 were present. At Sts. 368 and 369, both in the neighbourhood of Cook and Thule Islands, fifty and fifty-seven larvae respectively were taken, and at both stations Furcilia 1 predominated, but with Calyptopis 3 and Furcilia 2 and 3 also present.

The most notable feature in this line of stations is the increase in the number of larvae taken compared with that in the South Georgia area. The stages of development are in accordance with what was found in the South Georgia surveys. The record of Furcilia 6 so early in the year is noteworthy.

The larvae do not show an ordered arrangement in the degree of development from north to south, for at the first station where larvae are abundant Furcilia 1 predominates, at the next two to the south Calyptopis 1, and at the two southernmost Furcilia 1 again.

(4) Scotia Sea (Fig. 48)

	Stations	Locality	Year	Time of year
(*a*)	161–167 –170	South Georgia– South Orkneys– Elephant Island	1927	February
(*b*)	WS 374–381	South Georgia– South Orkneys– Elephant Island	1929	February
(*c*)	618–629	South Orkneys– South Sandwich– South Georgia	1931	February
(*d*)	633–638	South Georgia– South Orkneys	1931	March
(*e*)	372–375 WS 527–531	South Sandwich– Burdwood Bank	1930	March–April
(*f*)	WS 196–202	South Georgia– South Shetlands	1928	April
(*g*)	WS 203–209	South Shetlands– Burdwood Bank	1928	April

The stations in this section were all taken in the area bounded to the north, east and south by the Scotia Arc and on the west by the Drake Strait.

(*a*) South Georgia to the South Orkneys and Elephant Island, February 1927 (Sts. 161–170).

Vertical nets were fished at Sts. 160 and 161 between South Georgia and the South Orkneys, but only at the latter were larvae present. This station was situated about midway between the Shag Rocks and the South Orkneys, and at it eight larvae, all Calyptopis with the 2nd predominating, were taken. A single Calyptopis 2 was found at St. 167, the next vertical station made in the vicinity of the South Orkneys.

At St. 169, to the east of Clarence Island, the three Calyptopis stages and the 1st Furcilia were represented in a total of seventeen larvae, with Calyptopis 3 predominating.

(*b*) South Georgia to the South Orkneys and Elephant Island, February 1929 (Sts. WS 374–381).

At St. 376, midway between South Georgia and the South Orkneys, four adult male and two adult and gravid females were taken in the 750–500 m. net. At the next station to the south, St. WS 377, a single egg of *E. superba* was taken in the 250–100 m. net. Nothing was found at the two following stations, but at St. WS 380, midway between the Orkneys and Elephant Island, four eggs were found, two in the 250–100 m. and two in the 500–250 m. net. There were no larvae at St. WS 381.

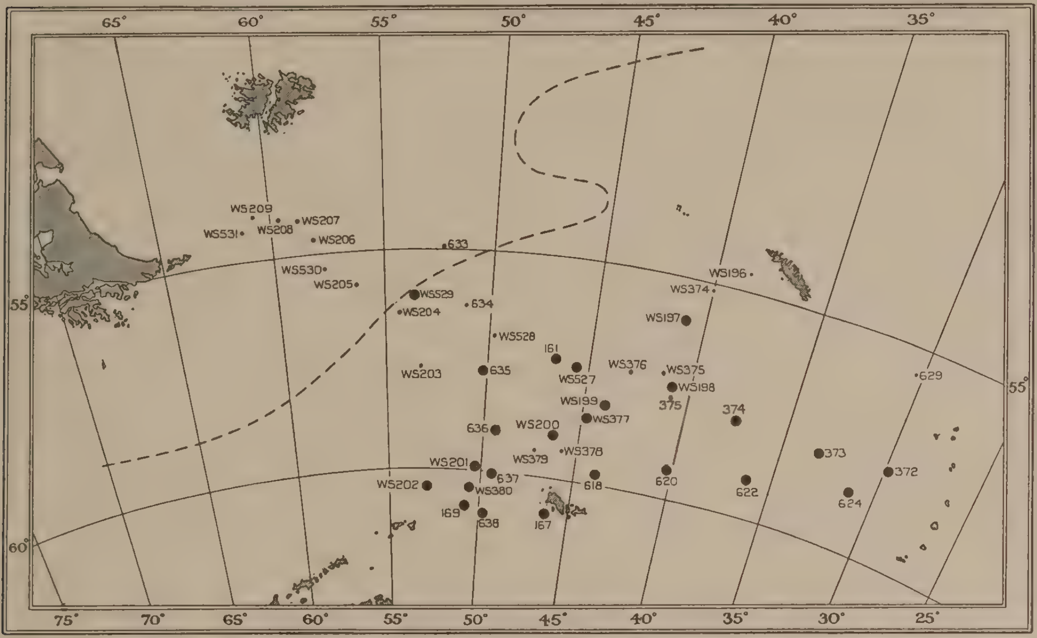
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Fig. 48. Distribution of young *Euphausia superba*, Scotia Sea (70-cm. net hauls).

(*c*) South Orkneys to the South Sandwich Islands and South Georgia, February 1931 (Sts. 618–629).

Vertical nets were fished at Sts. 618, 620, 622, 624 and 629.

At St. 618, the first station on this line, situated to the north-east of the South Orkneys, there were 985 larvae distributed from the surface down to 750–500 m. Calyptopis 1 predominated, but there were present also Metanauplii, deep down, and Calyptopis 2. At this station also an egg was found in the 250–100 m. sample.

At St. 620, larvae, totalling 243, were found in all the nets down to 1000 m. with the exception of the 500–250 m. haul. Calyptopis 1 was again the most plentiful with few Calyptopis 2 and Metanauplii, the latter being entirely confined to the lowest nets.

At St. 622 the number of larvae was much reduced, only forty-two being taken. With the exception of one Calyptopis 2 all were in the Calyptopis 1 stage. No Metanauplii were obtained at this station.

At St. 624 only one larva, a Furcilia 1, was obtained from the quarter sample of the 70-cm. net analysed. Ten Furcilia 1, four Furcilia 2 and one Furcilia 3 were taken in the 1-m. net.

There were no larvae at St. 629, between the South Sandwich Islands and South Georgia.

Of these stations, all up to St. 626 were taken in the proximity of the pack-ice edge.

(*d*) South Georgia to South Orkney, March 1931 (Sts. 633–638).

St. 633, the first vertical station on this line, was situated to the eastward of the Burdwood Bank, and with the succeeding one was made in sub-Antarctic water. At St. 635, the first station south of the Antarctic convergence, twenty-eight larvae representing stages from Calyptopis 2 to Furcilia 3 were found, with Calyptopis 2 and 3 in greatest number. At St. 636 there were sixty-four larvae from Metanauplius to Furcilia 1, with Calyptopis 1 predominating. The Metanauplii were all in the 750–500 m. net, whilst the remaining stages were distributed between 100 and 750 m. An egg, Metanauplii and Calyptopis 1 were found at St. 637, the egg at 250–100 m., the Metanauplii at 1000–500 m. and the Calyptopis between 100 and 1000 m. In all 129 larvae were taken, with Calyptopis 1 in greatest abundance.

At St. 638 the number of larvae was smaller, fourteen being taken. This station was made midway between the South Orkneys and Elephant Island, and only Metanauplii and Calyptopis 1 were taken. The Metanauplii were eight in number, and with the exception of one in the 250–100 m. net were in the two lowest nets. The Calyptopis were found between 250 and 750 m.

The last station (St. 639) on this line is better considered with the Bransfield Strait Stations, as it is situated midway between the South Orkneys and Joinville Island.

(*e*) South Sandwich Islands to the Burdwood Bank, March–April 1930 (Sts. 372–375 and WS 527–531).

This line of stations traversed the Scotia Arc in a diagonal course from east to west, crossing the Antarctic convergence between Sts. WS 529 and WS 530. The Discovery II stations were made between March 18 and 21, and those of the William Scoresby between March 30 and April 5.

At the first station (372) Furcilia 5 was in greatest abundance, with Furcilia 2, 3, 4 and 6 present: there were forty-one larvae in all.

Furcilia 5 was again predominant at St. 373, there being twenty-seven of this stage out of a total of thirty-seven larvae. Furcilia 2, 3, 4 and 6 were represented.

At St. 374 Furcilia 4 was the predominant stage with twenty-three out of a total of sixty-one larvae in which Furcilia 2–6 were present.

Furcilia 5 was once again the principal stage represented in the last Discovery II station: Furcilia 2, 3, 4 and 6 were also present.

No less than 756 larvae, distributed between the surface and 500 m., were obtained at St. WS 527. The larvae have been described in another section of this paper, in which attention was drawn to the great variety of forms encountered. At this station, for the first time on this line, Calyptopis were present. Furcilia 2 was the principal stage, and in addition Furcilia 1, 3, 4, 5 and 6 were represented. No larvae were recorded from St. WS 528. At St. WS 529 101 larvae were taken with Furcilia 3 predominating and Furcilia 2, 4, 5 and 6 present.

Sts. WS 530 and WS 531 were in warm water and no *E. superba* were recorded.

(*f*) South Georgia to the South Shetlands, April 1928 (Sts. WS 196–202).

St. WS 196 was made in shallow water to the south-west of South Georgia and no larvae were taken.

At St. WS 197 Calyptopis and Furcilia 1 were taken in the upper nets and nothing but the Metanauplius in the lowest net. Down to 750 m. Calyptopis 1 was the principal stage and below that only the Metanauplius was obtained. There were 209 larvae altogether.

Very few larvae were obtained at St. WS 198, the three Calyptopis stages and Furcilia 1 being represented with the latter predominating in a total of nine.

There were sixty-two larvae at St. WS 199, of which Furcilia 1 was the most prominent; in addition Calyptopis 3 and Furcilia 2 and 3 were present.

At St. WS 200 there were 154 larvae, with Furcilia 1 again the principal stage and Calyptopis 3 and Furcilia 2 and 3 also present.

The number was reduced to twenty-nine at St. WS 201, with the same stages represented as before and the same principal stage.

At St. WS 202, to the north-east of Elephant Island, twelve larvae were taken in which Calyptopis 2 and Furcilia 1 and 2 were present with Furcilia 2 the principal stage.

(*g*) South Shetlands to the Burdwood Bank, April 1928 (Sts. WS 203–209).

This line was made immediately after that just described, and no larvae were taken.

The observations in the Scotia Sea emphasize the general and widespread distribution of *E. superba* larvae within that part which is south of the Antarctic convergence. The occurrence of the different developmental stages is broadly what would have been anticipated from the foregoing observations. In February, in three different seasons, Calyptopis 2 is the predominant stage, showing that spawning must have commenced at about the same time as was indicated in the South Georgia region. But although in February 1931 Calyptopis 2 predominated there is a reversion of predominance to the previous stage in a line to the westwards made in March 1931. In March–April 1930 Furcilia 2–5 are most prominent; in April 1928 there is a reversion of predominance to earlier stages. It is thus obvious that in the same season, but in different localities of the same area, there is quite considerable variation in the degree of development at comparable times. It also demonstrates that different stages may predominate at the same time of year in different years.

The series of stations 618–639 requires particular attention. At each of the vertical stations along the ice-edge, larvae were taken in considerable quantity, which diminished in amount from west to east. From St. 625 onwards no larvae were taken. Compare these results with those described by Mackintosh (1934, p. 128, fig. 45) for this line of stations. He states:

> In February the 'Discovery II' returned to the South Sandwich region working stations along the ice-edge between the South Orkney Islands and the Sandwich Group. These stations (618–629) are shown in Fig. 45. The ice line had retreated very little since December but the plankton had changed to a much warmer type....None of the very "cold" group was present but such warm water species as *Pareuchaeta*, *Pleuromamma* and *Euphausia frigida* were included in the catches. As the ship approached the South Sandwich Islands, however, signs of a "colder" plankton appeared. *Vanadis* occurred at St. 624 and *Diphyes antarctica* at Sts. 625, 626, 628 and 629.

That is to say that the young krill, though admittedly taken at the ice-edge, were obtained exclusively in the region of Mackintosh's "warmer" plankton. Mackintosh states that the presence of ice does not necessarily entail the presence of cold-water plankton. This is a point to be emphasized, that the presence of the larval krill at the pack-ice edge does not mean that it is a "cold" species. This is borne out by the line from South Sandwich to the Burdwood Bank in March–April, 1930. The whole of this line was in a region where conditions for the occurrence of "warmer" plankton were prominent, and at each of the stations excepting St. WS 528, young larvae were present in an abundance which was conspicuous at St. WS 527 and WS 529, where the water was even warmer than at the preceding stations.

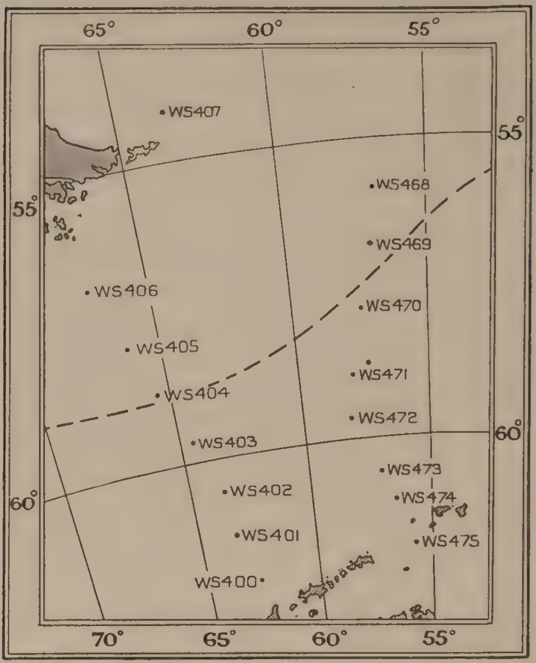
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Fig. 49. Distribution of young *Euphausia superba*, Drake Straits (70-cm. net hauls), February and November 1929.

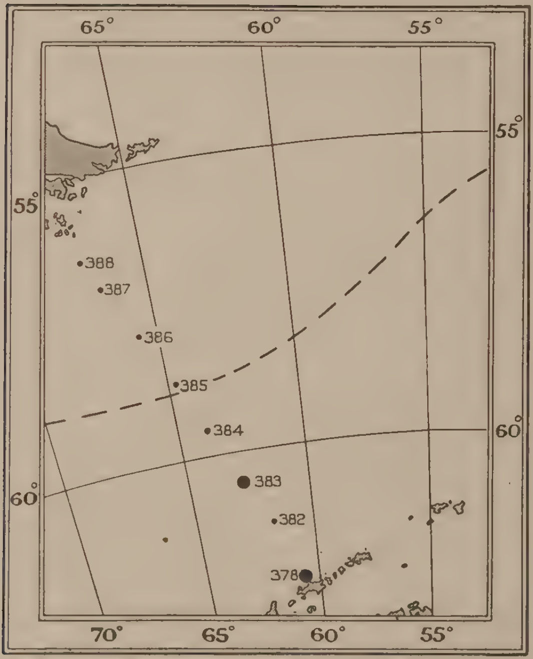
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Fig. 50. Distribution of young *Euphausia superba*, Drake Straits (70-cm. net hauls), March 1931.

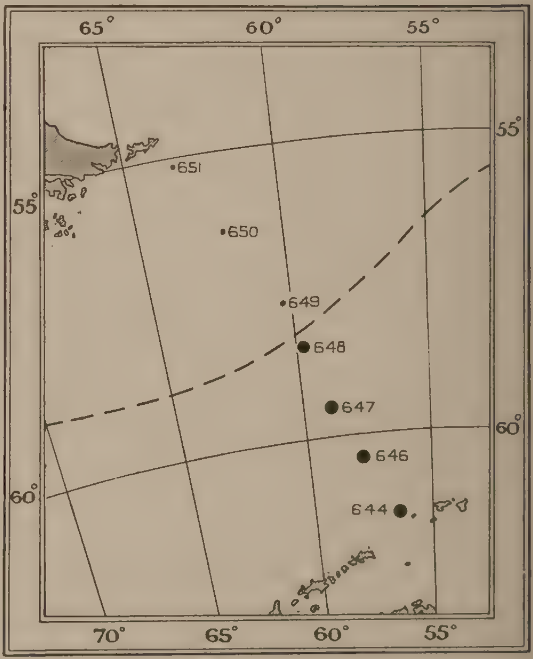
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Fig. 51. Distribution of young *Euphausia superba*, Drake Strait (70-cm. net hauls), April 1930.

(5) Drake Strait

	Stations	Year	Time of year
(*a*)	WS 468–475	1929	November
(*b*)	WS 400–407	1929	February
(*c*)	644–651	1931	March
(*d*)	378–388	1930	April

(*a*) and (*b*) yielded no eggs or larvae (Fig. 49).

(*c*) March 1931 (Sts. 644–651). Fig. 50.

This line of stations was made rather to the east of the Drake Strait from a point west of Elephant Island towards Staten Island. Of seven stations at which vertical nets were fished four were south of the Antarctic convergence and at all of these eggs and larvae were taken.

At St. 644 a few eggs only were taken and at St. 646 eight Calyptopis 1 and 2, with the latter stage predominating. 5200 larvae representing Metanauplius, Calyptopis 1 and 2 were taken at St. 647. The Metanauplii, 4279 in number, were confined to the two lowest nets between 500 and 1000 m. The Calyptopis were distributed throughout the six nets with greatest concentration in the surface net.

There were eighty Metanauplii and Calyptopis 1 at St. 648, with the Metanauplii predominating. The conditions at this station have been mentioned above, p. 115.

No *E. superba* were taken at the remaining stations north of the Antarctic convergence.

(*d*) April 1930 (Sts. 378–388). Fig. 51.

This line of stations was made immediately after the completion of the combined Discovery II-William Scoresby line (4(*e*)), from the South Sandwich Islands to the Burdwood Bank. It will be remembered that in that line Furcilia 5 predominated in the east and Furcilia 2 and 3 in the west. Vertical nets were worked at eight stations in the present line. Four of the stations were south of the Antarctic convergence and the remainder in warmer water.

Larvae were taken at Sts. 378 and 383, the first and third stations of the line. There were few larvae at the former, eleven in all, representing the three Calyptopis stages with the 2nd predominating. Larvae were once again abundant at St. 383, 787 being taken between 50 and 250 m. The three Calyptopis stages and Furcilia were represented, with Calyptopis 3 predominating.

The Drake Strait lines are chiefly important for the yield of the Metanauplius stage which one of them presents. The regional occurrence of this larval stage has been mentioned previously (p. 114), and its preference for warmer water pointed out. At both lines of stations from which we have records of larvae the greatest concentration is to the northward rather than the southward, and in the warmer rather than the colder water. These concentrations are of larvae having young stages predominant, in the one line Metanauplius and in the other Calyptopis 3.

Both lines were made late in the summer season, yet such early stages as Metanauplius and Calyptopis 1 were still obtained, which shows that in this species, unless of course development is delayed in some of the young larvae, the time range of spawning is not restricted to a short, definite period.

(6) Bransfield Strait surveys

	Stations	Year	Time of year
(*a*)	WS 476–493	1929	November
(*b*)	537–555	1930	December
(*c*)	WS 382–399	1929	February
(*d*)	171–177	1927	February–March
(*e*)	639, 644	1931	March
(*f*)	193–209	1927	March–April
(*g*)	376–377	1930	April

(*a*) Survey of November 1929 (Sts. WS 476–493). Fig. 52.

Eggs were taken at several stations in this survey. They were in greatest abundance between King George Island and Trinity Land, where eighty-three are recorded from St. WS 480 at depths between 100 and 500 m.; at St. WS 477 there was one egg between 1000 and 500 m. At each of the stations in the middle line between Livingston and Astrolabe Islands eggs were taken in very small quantity, never more than five at any one station, in nets fishing between 250 and 950 m. None were found in the Smith Island to Brabant Island line, but four Nauplius 2 were recorded, one at St. WS 480 and the remainder in the middle line.

(*b*) Survey of December 1930 (Sts. 537–555). Fig. 53.

Eggs were taken at all the stations on the east line from Elephant Island towards Joinville and at the northernmost and southernmost but one of the King George Island to Trinity Land line. Nothing is recorded from any of the stations in the western line from Snow Island to Trinity Island.

(*c*) Survey of February 1929 (Sts. WS 382–399). Fig. 54.

Only four eggs were taken in this survey, three of them in two stations on the King George Island line and one at St. WS 394 in the vicinity of Deception Island.

(*d*) Survey of February–March 1927 (Sts. 171–177).

There was only one vertical net station near Cape Melville, King George Island, at which a Furcilia 1 was recorded.

(*e*) Survey of March 1931 (Sts. 639 and 644). Fig. 54 (inset).

St. 639, situated about midway between the South Orkney Islands and Joinville Island, yielded Metanauplii, the three Calyptopis stages and Furcilia 2. It was at this station that the Metanauplii, two in number, were found in the surface net. Calyptopis 1 predominated, there being 218 out of a total of 293 larvae.

At St. 644 near Elephant Island two days later, ten eggs only were taken.

(*f*) Survey of March–April 1927 (Sts. 193–209). Fig. 55.

At St. 193 at the west end of the Bransfield Strait between Smith and Trinity Islands, 120 larvae were taken with Calyptopis 3 predominating and Calyptopis 2 and Furcilia 1 also present.

There were 189 larvae taken at St. 194, with Calyptopis 3 again predominating, and Calyptopis and 2, and Furcilia 1 and 3 present.

At St. 196, off King George Island, only two Furcilia 4 were taken; at St. 197 thirty-two larvae were taken in which Calyptopis 2 and 3 and Furcilia 1, 2 and 3 were represented, Calyptopis 3 and Furcilia 3 were most prominent. At St. 198 there were eighty-seven larvae with Calyptopis 2 and 3 prominent and Calyptopis 1 and Furcilia 1, 2, 3 and 4 present. There were fifty-nine larvae at St. 199 including Calyptopis 2 and 3 and Furcilia 2, 3 and 4, with Furcilia 3 the most prominent. At St. 200, the last station on the King George Island line, three Furcilia 1 and 2 were taken.

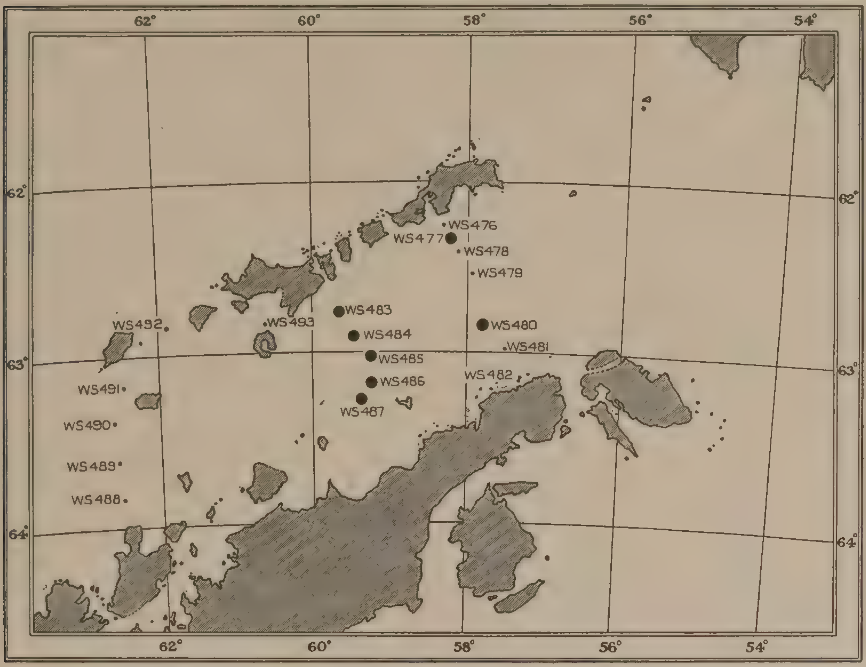
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Fig. 52. Distribution of young *Euphausia superba*, Bransfield Strait survey (70-cm. net hauls), November 1929.

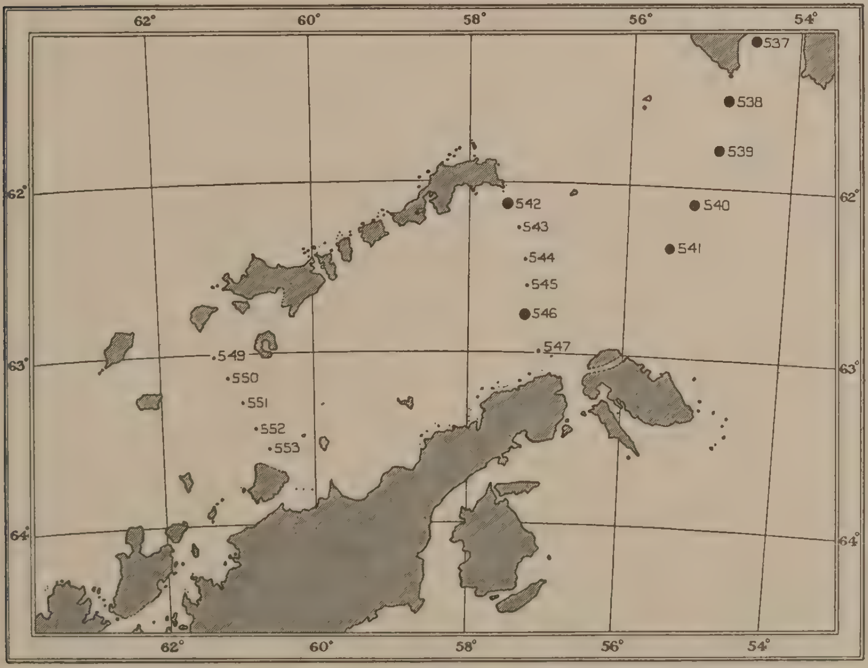
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Fig. 53. Distribution of young *Euphausia superba*, Bransfield Strait survey (70-cm. net hauls), December 1930.

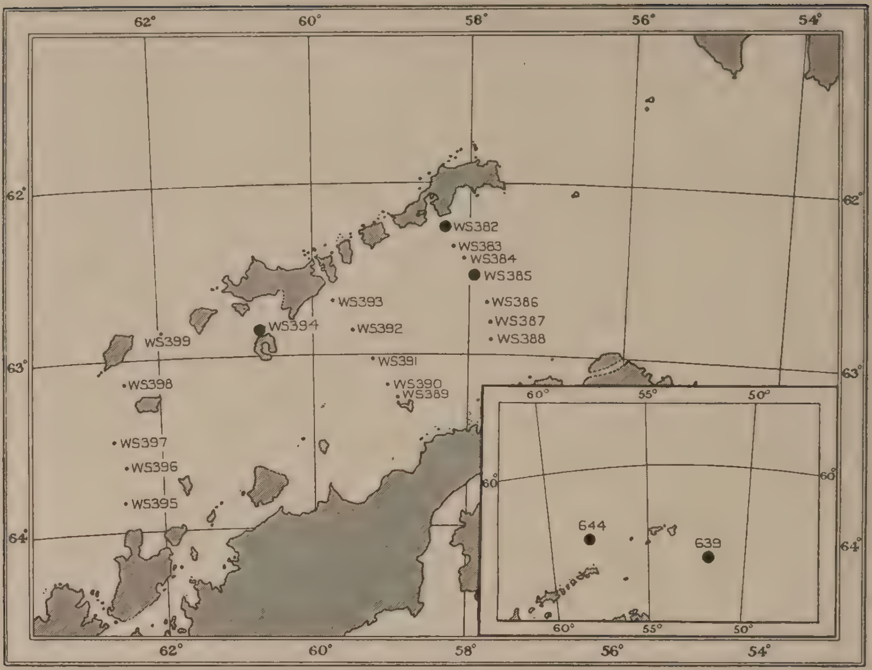
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Fig. 54. Distribution of young *Euphausia superba*, Bransfield Strait survey (70-cm. net hauls), February 1929, and inset March 1931.

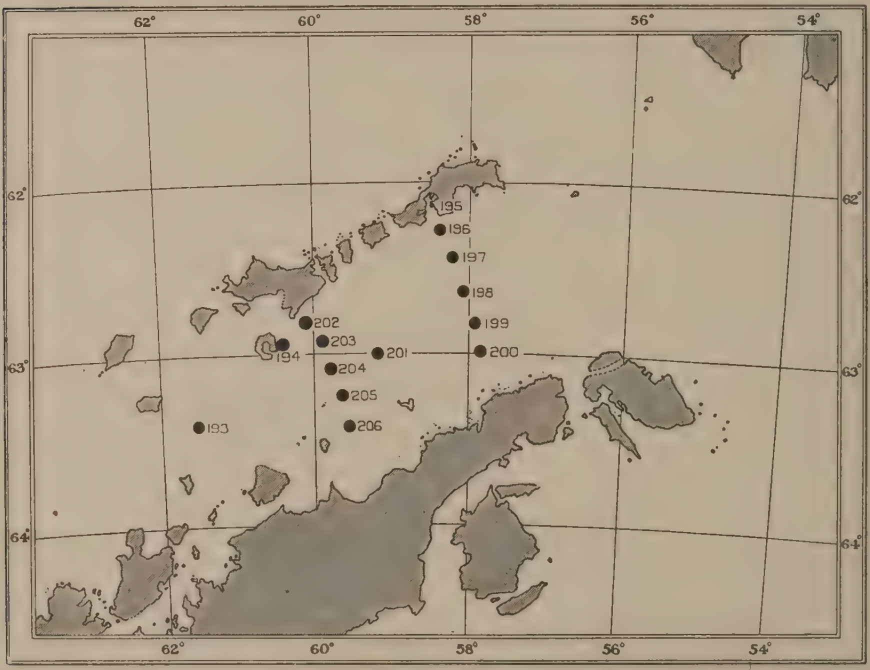
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Fig. 55. Distribution of young *Euphausia superba*, Bransfield Strait survey (70-cm. net hauls), March–April 1927.

At St. 201, between the east and west lines, there were seven larvae with Furcilia 2 and 3 exceeding in number Furcilia 4.

Larvae were taken at each of Sts. 202–206: sixteen with Calyptopis 3 predominating, at St. 202; seventeen, with Furcilia 3 predominating but no Calyptopis present, at St. 203; twenty-nine at St. 204 with Furcilia 3 again predominating and five at St. 205 with two each of Calyptopis 2 and 3, and one Furcilia 1; three larvae were found at St. 206, comprising two Calyptopis 2 and one Furcilia 3.

St. 209 in the middle of Deception Harbour yielded one Calyptopis 2.

(*g*) Survey of April 1930 (Sts. 376–377).

These yielded no *E. superba*.

The Bransfield Strait stations are noteworthy as the source of most of the records of eggs in the plankton examined. Their abundance at certain stations has been discussed in the section dealing with the distribution of eggs. Here it may be noted that in this area, so highly specialized as far as hydrographic conditions are concerned, there is, following the incidence of eggs early in the season, a widespread abundance of larvae in the March–April survey. In this last survey Calyptopis 3 predominates and Furcilia 3 is conspicuous, but there is no well-defined directional arrangement in the distribution of these stages.

(7) Palmer Archipelago and Bellingshausen Sea

	Stations	Year	Time of year
(*a*)	WS 495–517	1929–30	December–February
(*b*)	558–604	1930–31	December–January
(*c*)	178–192	1927	March

(*a*) December–February 1929–30 (Sts. WS 495–517). Fig. 56.

Twenty-one vertical stations were made west of Graham Land in the Bellingshausen Sea: at two only was there evidence of *E. superba*. St. WS 496 in 631 m. off Adelaide Island gave one adolescent and two eggs and two eggs were found at St. WS 505 south-east of Peter I Island.

(*b*) December–January 1930–1 (Sts. 558–604). Fig. 57.

Only nine vertical stations were made in the Bellingshausen Sea and only two eggs were found, at Sts. 558 and 585. The former station was off the Biscoe Islands and the latter on the line made off Adelaide Island.

(*c*) Palmer Archipelago in March 1927 (Sts. 178–192). Fig. 58.

Five vertical stations were made in the neighbourhood of Anvers and Brabant Islands, but only two Calyptopis were taken—at St. 187 in the Neumayr Channel.

The scarcity of plankton in the Bellingshausen Sea has been noted by Mackintosh (1934), and *E. superba* is no exception to the general rule. Most of the stations, however, were taken at a time of year when it would not be expected that many larvae would be found, and although the adolescents, as will be seen later, were also few in number I do not think that the evidence obtained here is sufficient to form any general conclusion about the occurrence of very young larvae in this region.

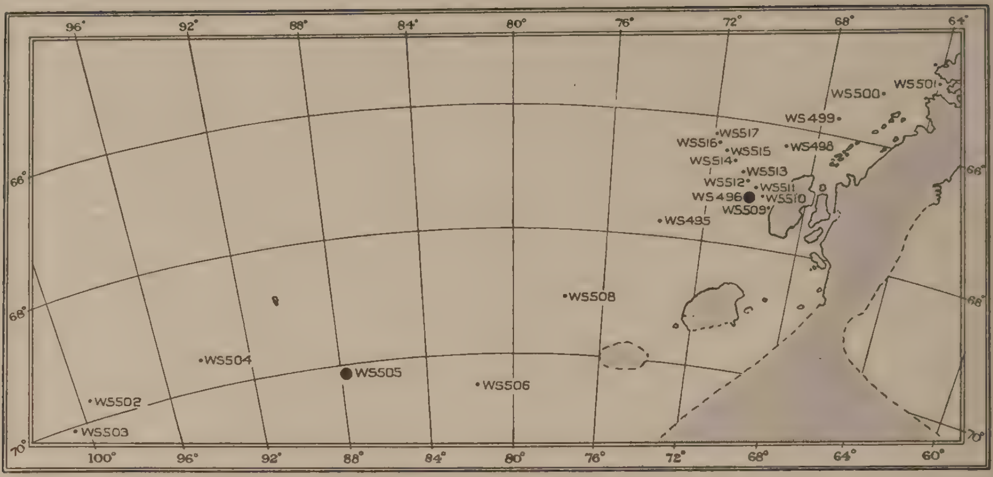
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Fig. 56. Distribution of young *Euphausia superba*, Palmer Archipelago and Bellingshausen Sea (70-cm. net hauls), December–February 1929–30.

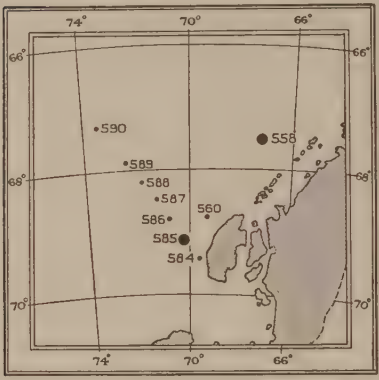
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Fig. 57. Distribution of young *Euphausia superba*, Bellingshausen Sea (70-cm. net hauls), December–January 1930–1.

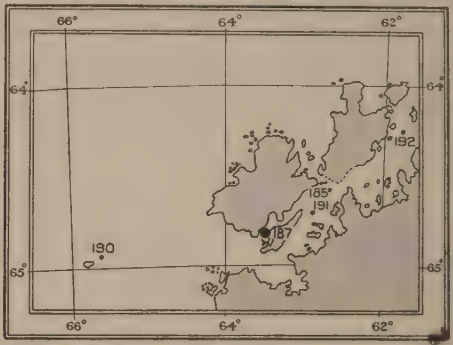
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Fig. 58. Distribution of young *Euphausia superba*, Palmer Archipelago (70-cm. net hauls), March 1927.

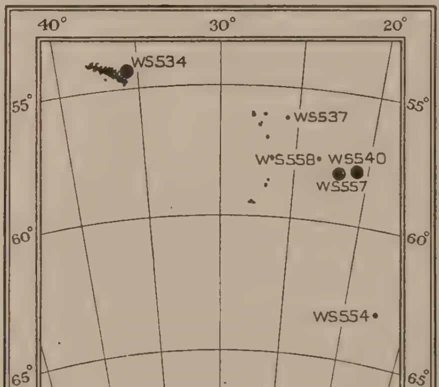
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Fig. 59. Distribution of young *Euphausia superba*, Weddell Sea (70-cm. net hauls), January–February 1931.

(8) East of South Georgia

(*a*) Sts. WS 297–310, observations in pack-ice in October 1928.
(*b*) Sts. 452–471, Cape Town–Bouvet–South Georgia in October 1930.

(*a*) October 1928 (Sts. WS 297–310).

At eight vertical stations made in the vicinity of pack-ice only six larvae were taken, three being Furcilia 6, two adolescent and one undetermined. They were found at Sts. WS 297, WS 307 and WS 310. The 1-m. nets, however, give a better indication of the occurrence of these forms.

(*b*) Cape Town–Bouvet Island–South Georgia, October 1930 (Sts. 452–471).

St. 452 was the first south of the Antarctic convergence on the track between Cape Town and Bouvet Island. No larvae were taken there in the vertical nets, and at the following stations only *E. superba* of the previous year class were encountered. Here again the 1-m. nets give a much better idea of abundance. Larvae were obtained at Sts. 453 and 471 only. At the former station one adolescent was taken in the surface net, and at the latter there were thirty-three Furcilia 6 and thirty-three adolescents, again in the surface net.

This section is important, if only in a negative manner, so far as younger stages are concerned. The stations were all taken very early in the summer season and no eggs or first season larvae were obtained.

(9) The Weddell Sea, January–February 1931
(Sts. WS 534–561). Fig. 59

A line of stations was made in January–February 1931 from South Georgia *via* the Sandwich Islands into the Weddell Sea as far south as 68° 53′. There were twenty-eight stations at eight of which vertical nets were fished. On the outward journey at St. WS 534 and WS 540 respectively, east of South Georgia and the Sandwich Group, Furcilia 6 and adolescents were taken in moderate quantity. On the return journey, at St. WS 557, one damaged juvenile was taken. No larvae or eggs were found in the Weddell Sea proper, and the 1-m. nets bear out this scarcity. In these nets the juvenile *E. superba* taken are entirely restricted to the northern stations, and are all of the previous year class. The numbers of *E. superba* in the 70-cm. vertical nets are as follows: St. WS 534 ninety-six; St. WS 540 twenty-five; St. WS 557 one.

MATERIAL OBTAINED DURING THE CIRCUMPOLAR CRUISE

A general account of this cruise of the R.R.S. 'Discovery II' is given by John (1934). A series of voyages to and from the ice-edge on a course east-about from South Africa to South America was made during the winter months, and the importance of these, so far as the present investigation is concerned, is twofold. The observations were the first made in the winter months, and they were made in regions of the Antarctic from which we had not previously had plankton samples. John picked out the young *E. superba* and sent them to me, together with valuable notes of the environmental conditions in which the larvae were taken. I have also had access to the scientific reports sent by him to the Discovery Committee.

The observations are derived from the records of the 1-m. net hauls and not from the 70-cm. vertical net hauls. In a previous section attention was drawn to the selectivity of these nets, and it was pointed out that the larger nets give a better indication of the presence of larger larvae. At the time of year when the circumpolar cruise was made, larger, rather than smaller, larvae were to be found, so that the records obtained form a useful link both in time and developmental stages between those of the 70-cm. nets, concerned chiefly with larvae of the first year class, and those of the 1-m. nets examined with special reference to larvae of the second year class.

The following is a list of the sections into which the stations of the cruise have been subdivided (see Fig. 60):

(*a*) Cape Town–Enderby Land–Fremantle, April 1932.
(*b*) Fremantle–Adélie Land–Melbourne, May 1932.
(*c*) Melbourne–ice-edge–New Zealand, June 1932.
(*d*) New Zealand–ice-edge–subtropical convergence, September 1932.
(*e*) Bellingshausen Sea, October–November 1932.
(*f*) South Georgia–ice-edge–Cape Town, March 1933.

In the section (*e*) incidental reference is made to catches of young krill from the vicinity of South Georgia and from the Weddell Sea, with which the krill from the Bellingshausen Sea is compared.

(*a*) Cape Town–Enderby Land–Fremantle, April 1932 (Sts. 843–876).

The first cruise began at Simonstown on April 8, and at St. 852, four stations north from the turning point at the ice-edge, krill was taken. Larvae were found in increasing amount until the ice-edge was reached.

One Furcilia 2 was found at St. 852. At St. 853 six larvae representing Calyptopis 3, Furcilia 1 and 2 were taken, with the Calyptopis predominating. Nineteen larvae were taken at St. 854, with Calyptopis 3 predominating and Calyptopis 2 and Furcilia 1 present. At St. 855 close to Enderby Land, there were 575 larvae in the surface net with Calyptopis 3 predominating and Calyptopis 2 and Furcilia 1, 2 and 3 represented. In the lower net there were four Calyptopis 2 and six Calyptopis 3.

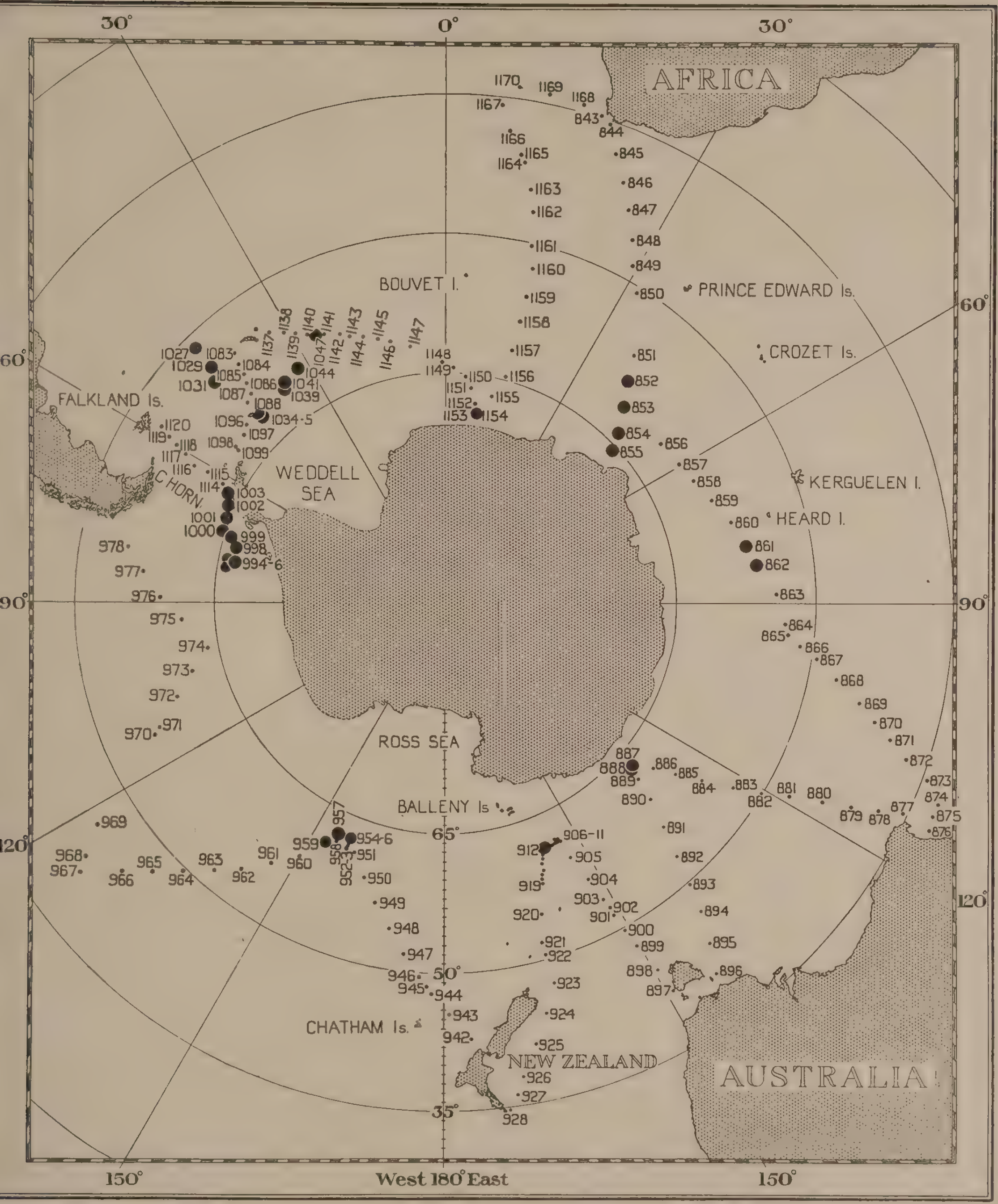
No larvae were taken again until St. 861, where deep and shallow nets were towed. In the shallow net were 131 larvae, and in the deep 86. No Calyptopis were taken but Furcilia 1–5 were present with Furcilia 2 predominating. At St. 862 most of the larvae (39) were again concentrated in the upper net; in the lower net there were five. Furcilia 1–6 were present with Furcilia 4 the most abundant.

John suggests that the presence of larvae at Sts. 861 and 862 was due to the stations having been made where the surface layer was of cold Antarctic water deflected northwards along the west side of the Kerguelen-Gaussberg ridge.

The majority of the larvae, taken in April off Enderby Land, were Calyptopis with a rise to dominance of Furcilia 2 and 4 at Sts. 861 and 862.

(*b*) Fremantle–Adélie Land–Melbourne, May 1932 (Sts. 877–896).

On the second visit to the pack-ice only small numbers of larvae were obtained. John states that they met young pancake-ice in 63°·41½′ S as darkness fell. A station (887) was made and larval krill was taken. John had hoped that on the following day they would find the pancake-ice had formed a narrow fringe along pack-ice near which he anticipated finding large numbers of krill larvae: but during the night pancake-ice began to form around the ship, so she turned and steamed northwards making St. 888, twenty-five miles from the edge of the ice.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ROSS SEA
WEDDELL SEA
C. HORN
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PRINCE EDWARD Is.
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Fig. 60. Distribution of young *Euphausia superba*, circumpolar cruise.

At St. 887 in the pancake-ice seventy-two larvae were taken in four different net hauls. No stage earlier than Furcilia 2 was recorded, which was the most abundant form; Furcilia 3, 4 and 5 were also present. Only one of the larvae was taken in deep water, the remainder being caught in horizontal nets towed at the surface or oblique nets fishing about 100 m.

At St. 888 there were twenty-six larvae comprising Furcilia 2 and 3, with the former predominating.

The small number of larvae obtained on this second visit to the ice-edge led John to believe that large numbers of larvae were to be expected, not in the young newly formed pancake-ice, but along the edges of the older pack-ice. This influenced the observations made on the third visit to the ice-edge between Melbourne and New Zealand in late June.

(*c*) Melbourne–ice-edge–New Zealand, June 1932 (Sts. 897–928).

In June, on the third journey southward, the ice-edge was encountered in 61° S, farther north than on either of the two previous occasions. The ship met light pancake-ice on the night of June 22 and steamed through it in search of pack-ice, but none was found, and the pancakes became too tightly packed to make a full station in darkness possible. The ship therefore steamed to the edge of the ice and made a full station, no krill or krill larvae being obtained. In the morning the 'Discovery II' again steamed into the pancake-ice but could see no sign of pack-ice to the south so she turned east and steamed through the pancake-ice, making three oblique towing stations at four-hourly intervals. No krill was taken at any of these stations nor at a station made at night at the edge of the ice. Throughout the night the ship steamed eastward parallel to the edge of the ice and entered it to continue the search the following morning. Oblique nets were towed and small numbers of late Furcilia were taken in the upper nets.

The 1-m. and 70-cm. nets were fished on the same warp just below the surface and clear of the ice; they were closed before hauling in. The 1-m. net was at a depth of 2 m. and caught large numbers of larvae; the 70-cm. net at 5–7 m. caught none. The nets were fished again in the same way with the same results. A full station was subsequently made in the ice but no young *E. superba* were taken in the vertical net hauls. They were caught again in large numbers in the 1-m. net, and on this occasion in the 70-cm. net, towed just below the ice at the end of the station.

Krill had been taken on the previous cruises some distance from the ice in the cold westward-flowing Antarctic water, but after leaving the ice on this last occasion, although oblique nets and a horizontal surface 1-m. net were towed every four hours until the boundary of the cold water was reached, neither adult nor larval krill was taken.

The sample of krill analysed, from the 1-m. horizontal net towed at 2 m. at St. 912, consisted of one-eighth of the total number, 1616. Furcilia 4, 5 and 6 and one adolescent were taken, with Furcilia 6 greatly predominating over the other stages found.

John states that the horizontal *surface* hauls near the ice were enormous compared with the oblique hauls.

(*d*) New Zealand–ice-edge–subtropical convergence south of mid-Pacific, September 1932 (Sts. 942–967).

The search for young *E. superba* along the ice-edge on this cruise resembled that made on the previous visit, but the number taken was much smaller. Two days were occupied in the search, and the night between was spent steaming eastwards along the ice-edge. Twenty-one net hauls were made in the ice and along its edge; eight of them were the routine oblique hauls from 250–100 m. or from 100 m. to the surface and thirteen were horizontal surface hauls made particularly for the purpose of catching young krill. The total number taken was small, approximately 220; only one adult was obtained.

At St. 954, 0–5 m., 108 Furcilia 6 and adolescents were taken, with the latter predominating. It was observed that, contrary to the usual length distribution of young *E. superba*, in this instance they fell into two well-defined length groups, the lower with an average about 13 mm. and the higher about

17·5–18 mm. These two maxima were not connected with the stage of development, for in the lower group Furcilia 6 and adolescents were present in approximately equal numbers, while in the upper the larvae were entirely adolescent. It cannot be, therefore, that the second length group is the result of the larvae moulting, with sudden increase of length from Furcilia 6 to adolescent. The first length group thus does not moult directly to the second.

At St. 959 there was a similar distribution of length groups, but not quite so well-defined. The larger group is still too small to be regarded as the young adults of the ensuing season. Our figures for the average length of adolescents show that normally they reach about 20 mm. by the end of the first half of their second summer season, so that they would be much larger nine months later. It is more likely that at each of Sts. 954 and 959 we are dealing with two different broods belonging to the same year class. It may be that the larger group originates from eggs spawned very early in the previous season or, as suggested by John in his report, concerning a similar length distribution of larvae late in the circumpolar cruise, the size difference may be due to better conditions for growth in certain areas, such as a more abundant diatom flora.

At St. 955 young *E. superba* representing Furcilia 6 and adolescents were taken, with the latter predominating. At St. 956 only two Furcilia 6 were taken and at St. 957 three undetermined stages. One adult and eighty young were taken at St. 959, with adolescents predominating.

(*e*) Bellingshausen Sea, October–November 1932 (Sts. 968–1003).

The second portion of the W-shaped track from New Zealand to Magellanes was made in conditions which prevented the ship from reaching the ice-edge. Fuel was short and a prolonged gale interfered with the programme arranged. The ship turned northwards again in 63° 57′ S, 101° 16′ W with clear water to the southward. No krill was taken.

From Magellanes another V-shaped cruise was made at the end of October and beginning of November, south to the edge of the pack-ice and then north-east roughly parallel to the Graham Land Coast.

Young krill, but no adults, occurred in very small numbers in nine of the ten stations made along and near the pack-ice—the total number from both the oblique 1-m. and 70-cm. nets and the horizontal surface nets was only 170 individuals, 113 of which were taken at the northernmost station (1003). Furcilia 6 predominated, whereas south-east of New Zealand in September adolescents and Furcilia 6 were in about equal numbers if the second larger length group is ignored; adolescents greatly preponderated if the larger group is included.

The Bellingshausen Sea krill were measured by John, and later the small numbers taken at Sts. 1027 and 1031, and 200 young from a large haul of mixed old and young krill from St. 1029, were measured. These stations were to the north-west, south-west and west of South Georgia, far from the ice. A third batch of young krill, taken from six stations near to the Weddell Sea ice (Sts. 1034, 1035, 1039, 1041, 1044, 1047) was measured by John.

The length-frequency distribution of these three samples of krill is shown in the graphs in Fig. 61.

The young krill from the Bellingshausen Sea (*A*) were taken between October 29 and November 2; they were small. An analysis of the young krill taken south-east of New Zealand seven weeks earlier showed it to be composed of two size groups falling about the lengths of 12 and 20 mm. The majority of the Bellingshausen Sea krill were 12–14 mm. long and would have been a millimetre or two less in early September.

The young euphausians from the open sea to the west of South Georgia (*B*) and those from the Weddell Sea ice-edge (*C*), all of which fall about the lengths of 24–25 mm., were taken between November 18 and 30, that is two to four weeks later than those from the Bellingshausen Sea. The period between the observations is not sufficient to account for the great difference in size. The similarity of the two populations represented by the curves (*B*) and (*C*), together with Deacon's discovery of the existence of a constant flow of water from the Weddell Sea towards the Shag Rocks, makes it certain that the krill in the open water to the west of South Georgia was of Weddell Sea origin. It is suggested by John that better conditions for growth in the ice-free water, such as the more abundant diatom flora, may account for their larger size compared with those taken immediately afterwards along the ice-edge.

The graph *C*, representing the Weddell Sea ice-edge yearling krill, is the only one of the three graphs having two peaks showing two widely separated size groups in the population; but, as John remarks, more knowledge is necessary to understand what it and the two smaller and less widely separated size groups in the Bellinghausen Sea yearling krill mean.

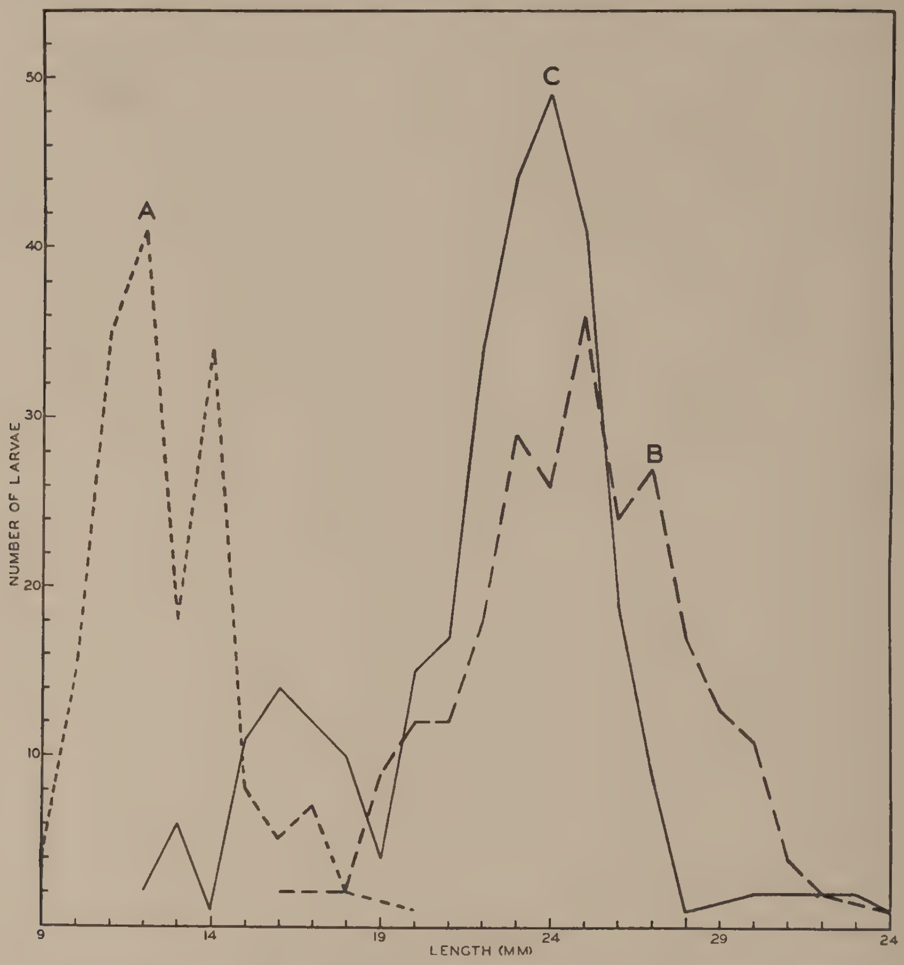

Fig. 61. Analyses of length frequencies of samples of young *Euphausia superba*: *A*, Bellingshausen Sea; *B*, South Georgia; *C*, Weddell Sea ice-edge.

(*f*) South Georgia–ice-edge–Cape Town, March 1933 (Sts. 1137–1167).

The last of the V-shaped sections of the circumpolar cruise from South Georgia to the ice-edge far to the east and south, and from there to Cape Town was made in March 1933.

I have not had the opportunity to examine the krill taken during this voyage but quote from John's report: "Although the places where we made many of our stations and the times at which we made them were places and times at which larval krill might have been expected we did not recognize any in our hauls.... Catches of large numbers of adult krill have been few although we continued to tow a surface metre net in addition to the oblique series at every station. We saw no krill patches. Near the ice-edge, in 69° S, 9° E, we followed our usual practice on such visits of towing net after net, until we obtained a quantity of krill. They were adolescents of an unexpectedly small size, the majority being a little smaller than those taken along the Weddell Sea ice-edge three months before."

The observations made during the circumpolar cruise are of great help towards a better understanding of the development and distribution of *E. superba*. The dominance of successive stages is made clear; in April Calyptopis 3 and early Furcilia stages are most abundant, in May Calyptopis stages have disappeared and Furcilia 2 predominates, in June it is Furcilia 6 and in September adolescent forms which have the chief place.

The concentration of the larvae at the ice-edge with the coming of winter is demonstrated. In April it is found that larvae occur both at the ice-edge and at a distance from it (Sts. 852–855), but in May, June and September they are concentrated exclusively at the ice-edge. It has been suggested above that at Sts. 861 and 862 the presence of larvae away from the ice-edge is connected with the deflection northwards of Antarctic surface water along the west side of the Kerguelen–Gaussberg ridge. In support of the suggestion that the larvae have been carried northwards in the surface water is the occurrence of typical ice-frequenting plankton at Sts. 861 and 862, and the absence of such plankton and young krill at five preceding stations, all of which, like Sts. 861 and 862, were made in the hours of darkness.

Movement southwards of the krill is ultimately limited by the ice-edge (see p. 159), and accumulation of larvae in that region is brought about by this limitation and augmented by the expansion of the area of ice-covered water with the coming of winter. At stations made in May, June and September no krill was found except at the ice-edge: its absence elsewhere can be explained if advance in time of year is brought into account. The southward movement of larvae developed in more northerly regions will have been terminated by the ice-edge being reached, and accumulation there will have been speeded up by the northward spreading of the ice field with the advent of winter conditions. In the Falkland sector it was found that in the summer larval krill was diffuse in its distribution, and there is no apparent reason against assuming a similar distribution in other parts of the Antarctic. On the other hand, the observations made during the circumpolar cruise give clear evidence of concentration in the vicinity of the ice-edge in winter. It is likely that the changes of distribution are brought about by the factors mentioned above.

MATERIAL CAUGHT IN THE 1-M. NETS

For information about the occurrence of larvae in their second season the data supplied by the oblique hauls of the 1-m. nets will be considered. The material is derived from stations made by R.R.S. 'William Scoresby' during the seasons 1928–9, 1929–30 and 1930–1; and by R.R.S. 'Discovery II' during the season 1930–1. The time of year covered is from August to February, but the number of observations for the latter month and January is very small.

It will be found convenient to take the stations in their chronological order, starting with the William Scoresby stations in August 1928.

Falkland Islands to South Georgia, August 1928 (Sts. WS 251–256). Fig. 62.

The Antarctic convergence was crossed between Sts. WS 253 and WS 254, and at the latter the first station to the southward of it a small quantity of young krill was taken. At the succeeding stations towards South Georgia krill was also present in small quantities. The stations which were made in late winter were nevertheless in ice-free water, no pack was encountered.

South Georgia survey, August–November 1928 (Sts. WS 257–285, WS 289–296, WS 311–313). Fig. 63.

The observations off South Georgia in the early part of the 1928–9 season were divided into three by two visits to the pack-ice to the east of South Georgia.

In the first set of observations, Sts. WS 257–285, four lines from Bird Island, Prince Olaf Harbour, Cape Larsen and Cape Vakop were made, between August 28 and September 18.

At every station, with the exception of two on the Bird Island line, young krill was taken in comparatively small numbers for the most part, but with indication of a rather greater concentration eastward of South Georgia at the outer stations of the Larsen and Vakop lines. On the last station on the Vakop line (St. WS 285), the largest catch of 1600 individuals was made.

From St. WS 285 the 'William Scoresby' steamed south to the edge of the not far distant pack-ice where, as will be seen in the next section, abundant krill was found.

The line from Cooper Island was completed at the beginning of October, and at each of the stations from WS 291 to 296 krill was taken. At the inner stations the quantity was small, whilst the two outer stations yielded moderately abundant amounts.

The three stations WS 311–313 to the eastward of South Georgia were made between October 10 and November 5, only one young euphausian being taken.

The pack-ice stations, September–October 1928 (Sts. WS 286–288, WS 297–310). Fig. 64.

On September 18, on the way from the outermost station on the Vakop line to the edge of the pack, St. WS 286 was worked, 900 young *E. superba* being taken. St. WS 287 was made inside light pack-ice a few miles from the edge; only a moderate number of krill was taken. St. WS 288, worked just outside the edge of the pack-ice, yielded over 20,000 young *E. superba* from one net haul. It is interesting to note that this last station was made during the day at 1410 hours and that the net was fished from 102 to 0 m., showing that in certain circumstances, if not invariably, the young *E. superba* do not obey the same rhythmic diurnal migration noted in earlier larval forms, but may remain at the surface during the hours of daylight.

On the second visit to the ice east of South Georgia, nearly all the stations (WS 297–310) were worked in the neighbourhood of the ice, and at every station, whether actually in close proximity to the pack or so far from it that no note of its presence has been recorded in the station list, krill was found. It should be noted that at such stations as WS 304 and WS 305, where the pack-ice was at some distance, there were as many young euphausians taken as at stations worked at the edge of or actually in pack-ice. When it is realized that the pack-ice is capable of considerable and rapid local movement, due to wind, one would not anticipate that the greatest concentration of the animals would necessarily be in the immediate proximity of the pack-ice, but rather that they should be distributed within the area of the ice-edge movement.

Falkland Islands to South Shetland, November 1929 (Sts. WS 468–474). Fig. 65.

The next line of stations is that made in November of the following year between Falkland Islands and South Shetland. At St. WS 468 made close to the Antarctic convergence one Furcilia 6 was taken, and at St. WS 474, west of Elephant Island, two Furcilia 6 and one adolescent. No krill was taken at the intervening stations.

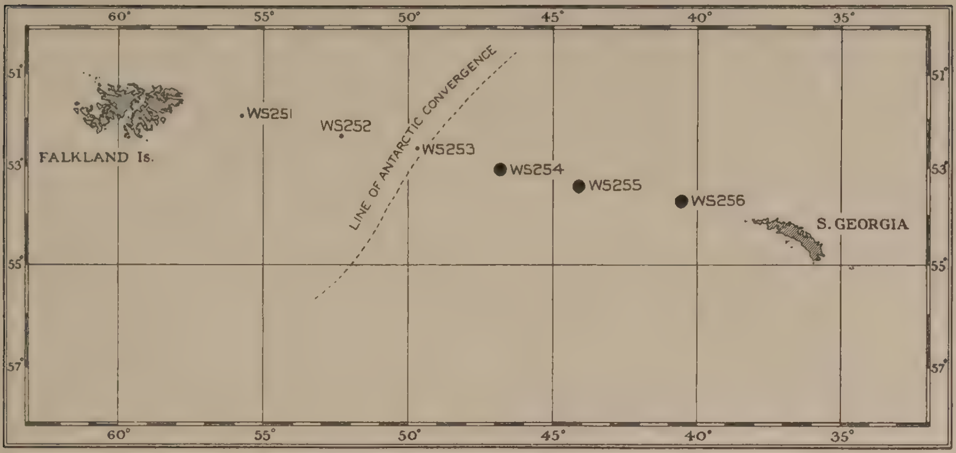
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Fig. 62. Distribution of young *Euphausia superba*, Falkland Islands–South Georgia (1-m. net hauls), August 1928.

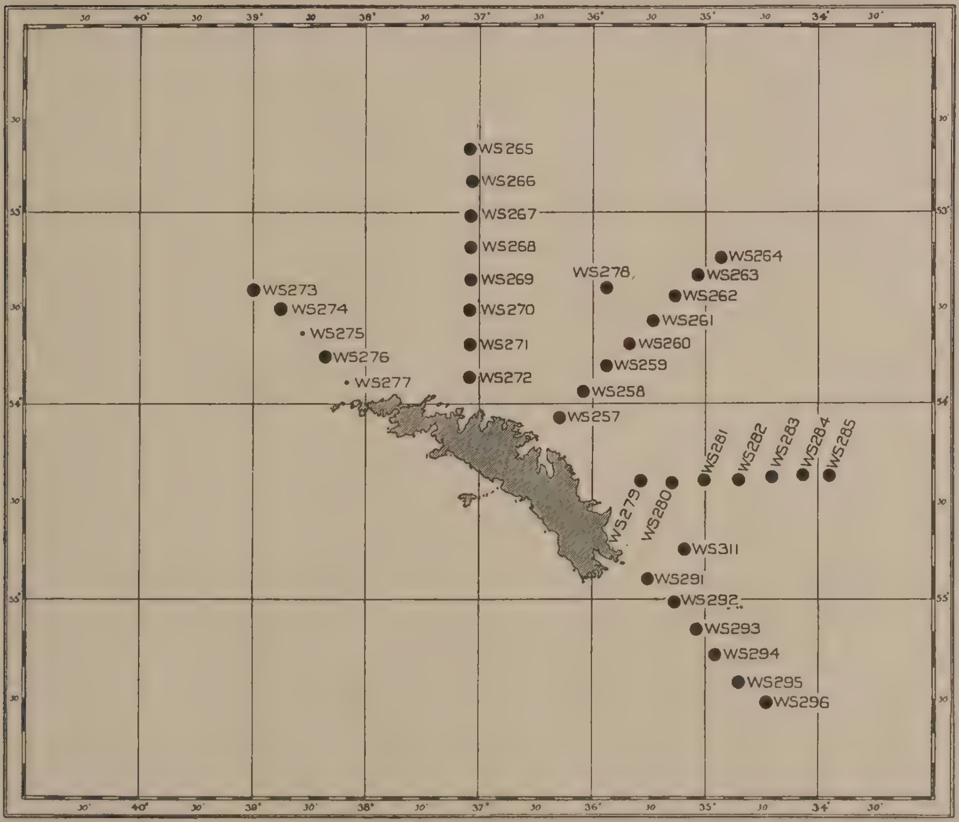
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Fig. 63. Distribution of young *Euphausia superba*, South Georgia survey (1-m. net hauls), August–November 1928.

Bransfield Strait survey, November 1929 (Sts. WS 475–494). Fig. 66.

In the November 1929 survey of the Bransfield Strait young *E. superba* were only abundant at one station (WS 487) at the southern end of the middle line. 1424 were taken, whereas at the remaining stations comparatively small numbers were recorded. The krill was distributed throughout the area of the strait, with an indication of greatest concentration on the Graham Land side.

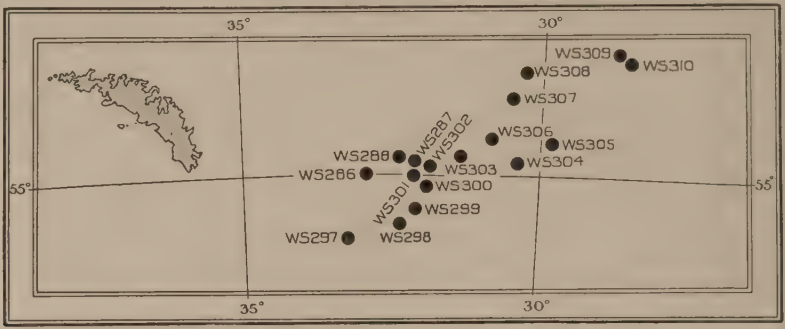
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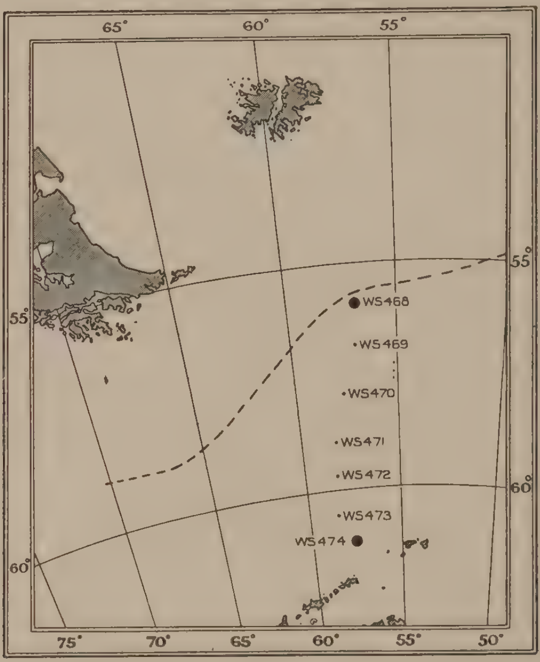
Fig. 64. Distribution of young *Euphausia superba*, pack-ice stations (1-m. net hauls), September–October 1928.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75°
70°
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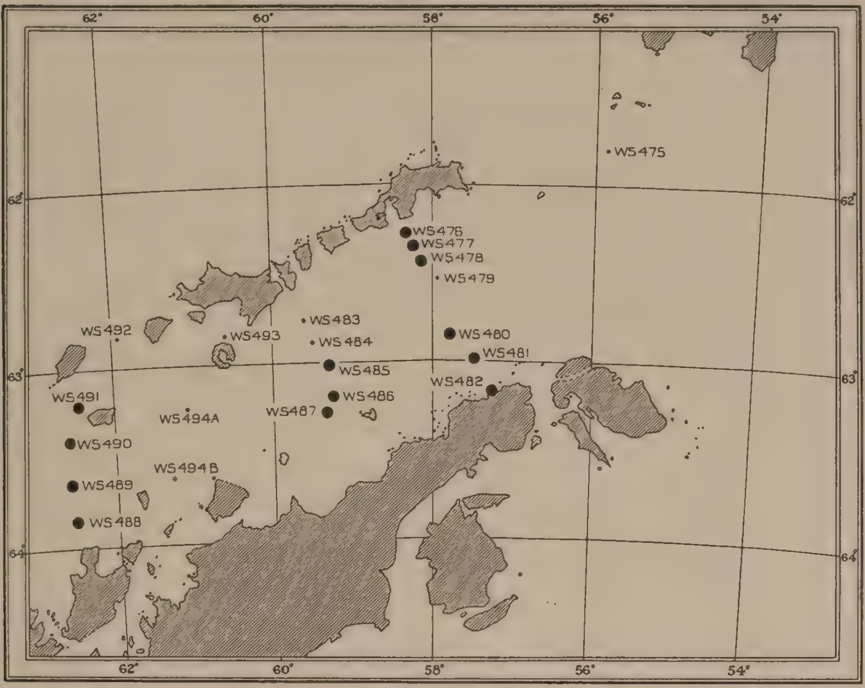
60°
55°
50°

Fig. 65. Distribution of young *Euphausia superba*, Falkland Islands to South Shetlands (1-m. net hauls), November 1929.

Bellingshausen Sea, December 1929–February 1930 (Sts. WS 496–517). Fig. 67.

The area covered by the stations in this section extends from Anvers Island westwards of Peter I Island to 100° W. The small quantity of krill taken is noteworthy. With the exception of a single individual at St. WS 508, north-west of Charcot Land, no krill was found to the west of Adelaide Island. The stations at which it was present, with the exception just mentioned, were all situated off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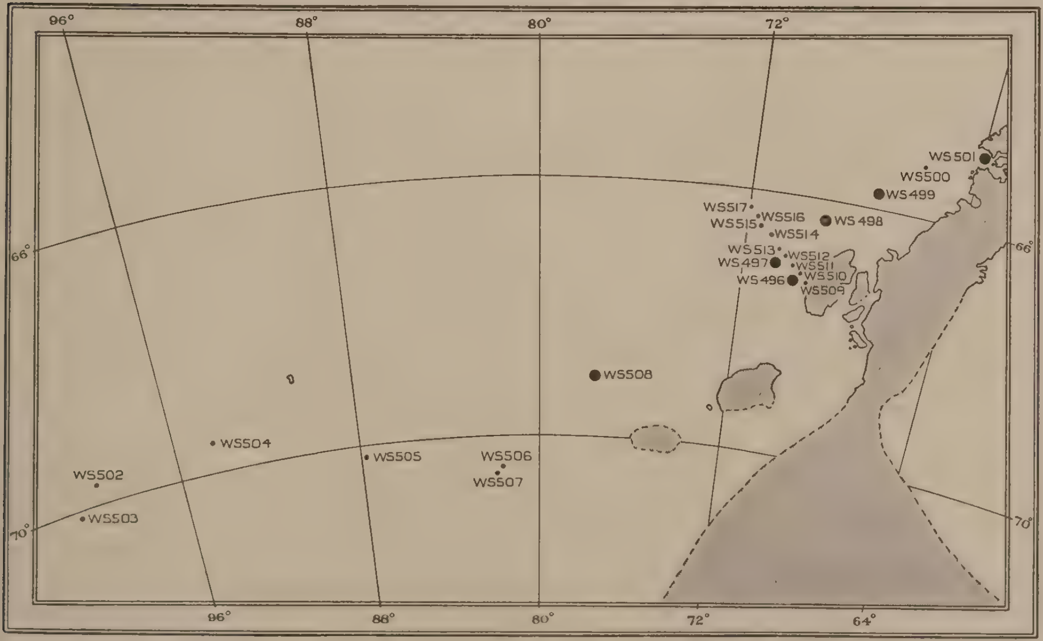
WS494B

Fig. 66. Distribution of young *Euphausia superba*, Bransfield Strait survey (1-m. net hauls), November 1929.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WS506
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WS503

Fig. 67. Distribution of young *Euphausia superba*, Bellingshausen Sea (1-m. net hauls), December–February 1929–30.

the coast between Adelaide Island and Anvers Island, with greatest concentration off the former island. No krill was taken on the line of stations made to the north-west from Adelaide Island (Sts. WS 508–517).

Weddell Sea, January–February 1931 (Sts. WS 534–561). Fig. 68.

Towards the end of January 1931 the 'William Scoresby' sailed south-eastward from South Georgia, encountering pack-ice north of the South Sandwich Group. The ice was skirted to the eastward and was found to fall away to the south and east. The ship went southwards for about 600 miles in open water to 68° 53′ S, 13° 03′ W, where the pack was again encountered.

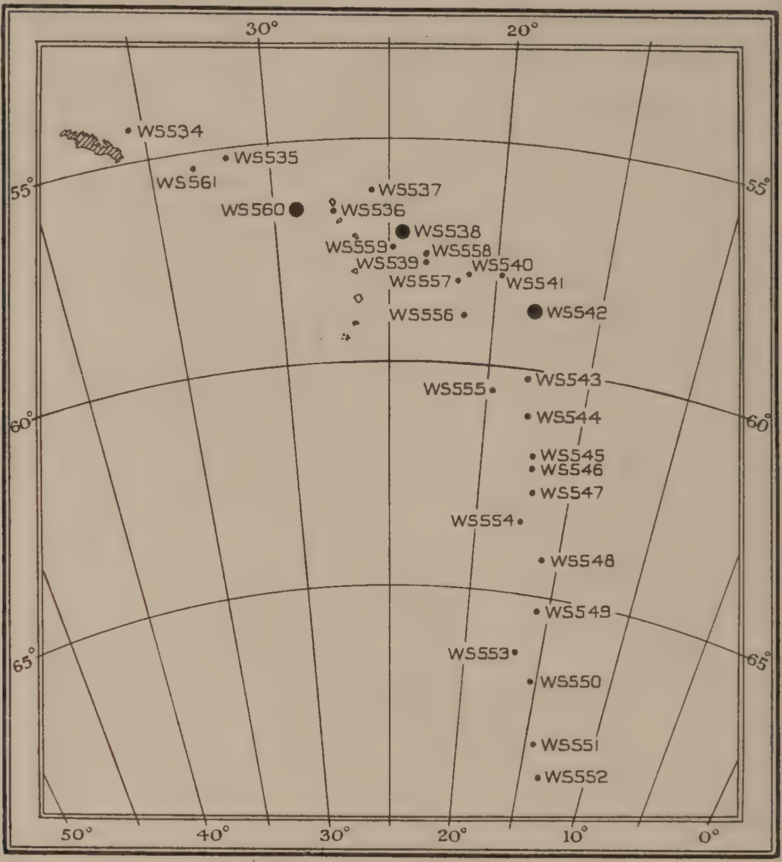
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Fig. 68. Distribution of young *Euphausia superba*, Weddell Sea (1-m. net hauls), January–February 1931.

The stations where krill was taken are all concentrated on the northern part of the line between South Georgia and the point east of the Sandwich Group, where the ship turned southward into the ice-free water of the eastern Weddell Sea.

At St. WS 534 ninety-six young *E. superba* were taken in the vertical nets. At Sts. WS 538 and WS 542 they were abundant in the 1-m. nets, over 5000 individuals being taken at each of these stations, and the vertical nets at St. WS 540 contained a moderate number. *E. superba* was absent from all the stations southward from WS 539, including the ice-edge station WS 552, at which six sets of observations were made over a period of twenty-four hours. Flights of five closing metre nets were fished, the lowest at about 500 m.; in none of these was young *E. superba* taken.

Returning northwards again it was not until the ship reached the region in which krill had previously been found that one individual, at St. WS 557, was again recorded in the vertical net series. A small quantity of krill was taken at St. WS 560 in the 1-m. net, to the westward of the north end of the South Sandwich Group.

Cape Town–Bouvet–South Georgia, October–November, 1930 (Sts. 446–472). Fig. 69.

In October 1930 the 'Discovery II' sailed southwards on a line of stations from Cape Town to Bouvet and South Georgia. The Antarctic convergence was crossed between Sts. 451 and 452. The first catch of young krill was made at St. 453 where a large quantity was recorded. At Sts. 453–455, all in the neighbourhood of Bouvet, a considerable quantity of krill was taken, at the last station over 6000. From Bouvet Island to South Georgia the track was along the edge or through the outskirts of the pack-ice. Young *E. superba* were taken at each of the stations where the metre net was fished. At St. 461 a twenty-four hours station was made, the results of which are dealt with in a separate section. At St. 468 no 100-cm. nets were fished. In his report on this series of stations Dr Kemp, referring to *E. superba*, states: "We found krill first of all to the N.E. of Bouvet where we took a quantity of adults and a great number of late larval and early post-larval forms, stages that we had scarcely seen hitherto. Along the pack adults were again taken at many points and at every station young have been obtained, usually in great abundance. When making our way through the pack, either in the main body of it or when crossing the narrow tongues, krill was almost always to be seen and often it occurred in great quantity. The young stranded themselves in numbers on floes that we momentarily submerged in our passage, while the adults, with greater activity, often jumped clear of the water and landed kicking on ice some 10 or 12 inches above the surface. The quantity of krill to be found in and near the pack at this season is amazing and the reason why whales haunt the ice-edge is evident."

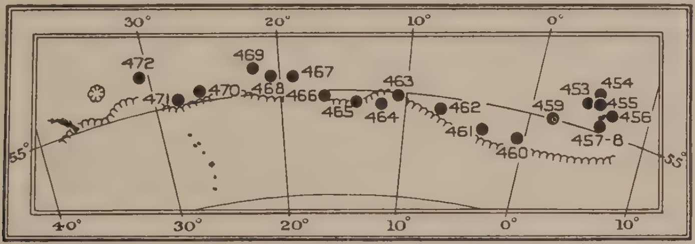

Fig. 69. Distribution of young *Euphausia superba*, Cape Town, Bouvet, South Georgia (1-m. net hauls), October–November 1930.

South Georgia survey, November 1930 (Sts. 474–525). Fig. 70.

After the completion of the Bouvet–South Georgia stations a plankton survey round South Georgia was commenced. At the beginning of the survey, as stated by Mackintosh (1934, p. 127), the pack-ice was close up to the island, but at the end of November when the survey was completed the ice had receded some way to the south-east. There can be no doubt that the abundance in which young krill was found in the vicinity of South Georgia during this survey was due to the proximity of the pack to the island, and it is likely that earlier in this season the ice-edge extended north and west to the positions shown on the map where krill was especially abundant. It is likely too that the surface currents (*vide* Deacon, 1933, p. 183, fig. 5) would tend to transport the krill northwards and eastwards in the tongue of water extending along the north-east coast of South Georgia.

South Shetland survey, December 1930 (Sts. 537–555). Fig. 71.

In this survey the distribution of the young krill was much the same as that of the eggs described on p. 109. The greatest concentration was at St. 537, the first on the Elephant–Joinville line: this

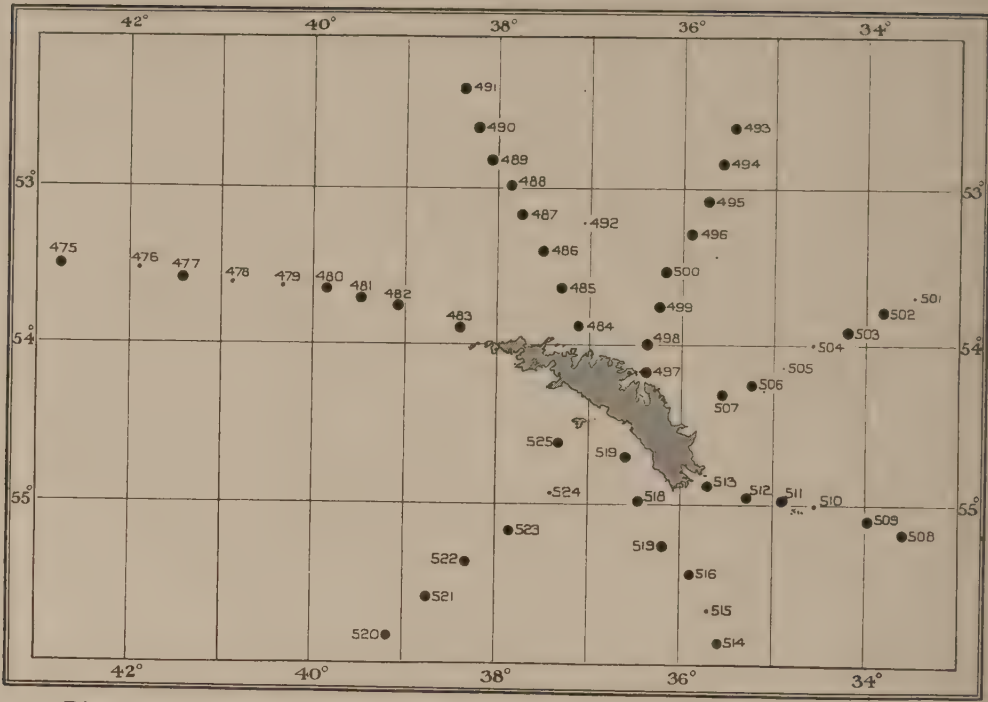
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Fig. 70. Distribution of young *Euphausia superba*, South Georgia survey (1-m. net hauls), November 1930.

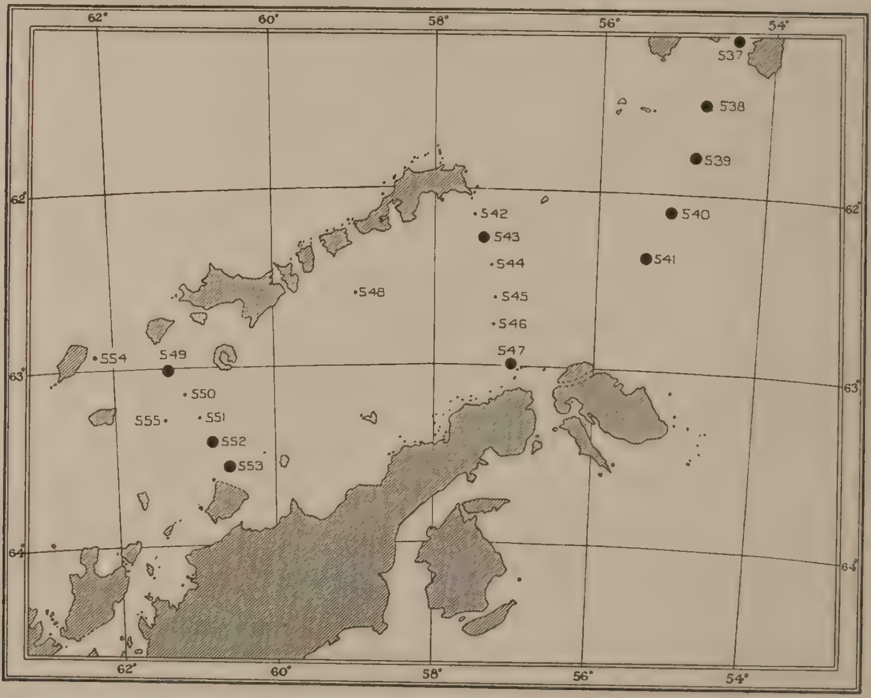
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Fig. 71. Distribution of young *Euphausia superba*, South Shetland survey (1-m. net), December 1930.

station is situated between Elephant and Clarence Islands and over 7000 young *E. superba* were taken. Much smaller numbers were taken at Sts. 538–541, but some were present at each of the stations.[1] On the Cape Melville–Trinity Land line krill was in very small quantity at Sts. 543 and 547, two individuals being obtained at each, and was absent from the remaining stations. On the Snow Island–Trinity Island line there were ten at St. 549 and one each at Sts. 552 and 553, the southernmost stations in that line.

VERTICAL DISTRIBUTION

In this section the vertical distribution and migrations of *E. superba* from Calyptopis 1 to adolescent will be described. It was shown previously (p. 116) that, whereas the Metanauplius tends to remain in the same position whatever the time of day, there was evidence in the later larval stages of a pronounced diurnal migration. Before going on to deal with this in detail, it may be well to mention the difference in our results from those which Ruud obtained from his material (Ruud, 1932). He states in the summary of his paper (p. 93) that *E. superba* is a surface species, and that both the adults and the young in his catches were taken, almost without exception, above 200 m. "In other words", he remarks, "it belongs to the Antarctic surface layer." That this statement does not apply to all stages of the life history is made evident by the examination of the present material. The distribution of the adults is not within the scope of the present paper except to the extent that they are associated with the distribution of eggs, but there is some reason for believing that the adults seek the deeper water for the deposition of eggs. So far as larval stages from Calyptopis to adolescent are concerned we can demonstrate that they are not by any means restricted to the first 200 m.

The routine 70-cm. vertical net hauls made at plankton stations covered a range of 1000 m. from surface downwards or from surface to within a few metres of the sea-bottom if the depth were less than 1000 m. Six hauls were made with closing nets, as follows: 50–0, 100–50, 250–100, 500–250, 750–500 and 1000–750 m. The nets were hauled at a constant speed of 1 m. per second.

The depth through which the two uppermost nets were hauled is one-third that of the next lower net and one-fifth that of the three remaining nets. In order, therefore, to make the actual number of individuals in any one net haul comparable with the remainder, it is necessary to employ the lowest common multiple, which is 15, to obtain corrected totals. In the diagrams used to demonstrate vertical migration (Figs. 72 and 73) the width in each column represents the numbers in a 50-m. vertical haul between the indicated levels expressed as a percentage of the total. The day is divided up into six periods of four hours each, and each station has been placed in the four-hour period during which the greater part or the whole of the vertical net series was fished.

The larvae have been arranged in six groups of increasing development, the first three of which comprise the three Calyptopis stages; the fourth includes Furcilia 1, i.e. larvae with non-setose pleopods; the fifth includes Furcilia 2–4 and the intermediate forms with six and four terminal spines; the sixth group comprises Furcilia 5 and 6, including what were formerly recognized as Cyrtopia stages.

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[1] For some reason not recorded these larvae were not measured. The numbers were: St. 538 twenty-three, St. 539 twenty-seven, St. 540 three and St. 541 nine.

Between six and seven thousand larvae have been examined in this analysis of vertical distribution. As might be anticipated, Calyptopis 1 is in greatest abundance, and the group made up by Furcilia 5 and 6 has the smallest number of individuals in it. It is difficult to say how greatly the difference in number is due to the superior efficiency of the 70-cm. net in catching Calyptopis as compared with the larger larvae, and to what

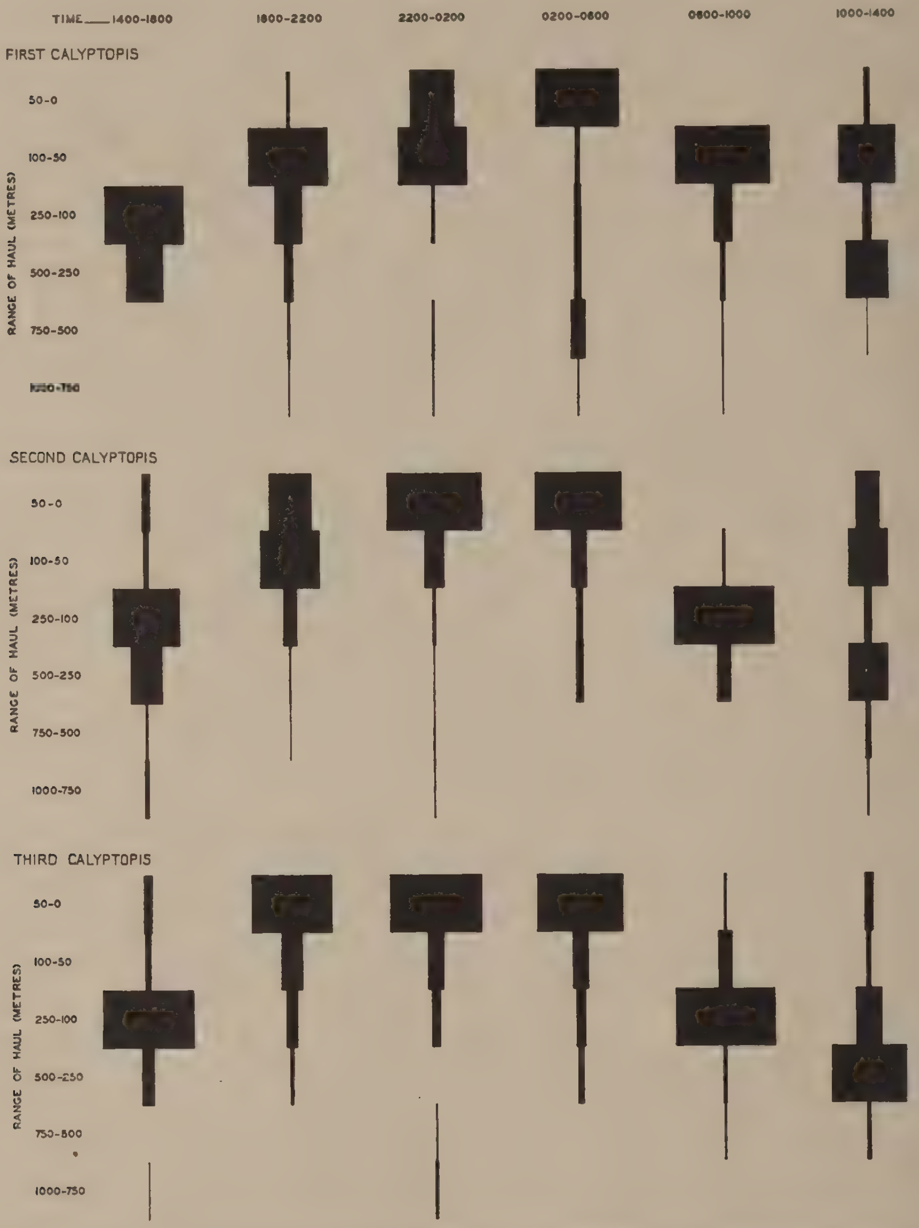

Fig. 72. Diagram showing diurnal vertical migration in Calyptopis 1–3 of *Euphausia superba*.

extent the numbers taken may be an indication of the comparative abundance of the two forms.

The six diagrams show that, with the exception of Furcilia stages 5 and 6, larval forms were present in greater or less abundance, from the surface down to 1000–750 m., the lowest depth to which nets were fished. In the Furcilia 5 and 6 the 750–500 m. net is the deepest in which larvae were discovered. But while it is true that the 1000–750 m.

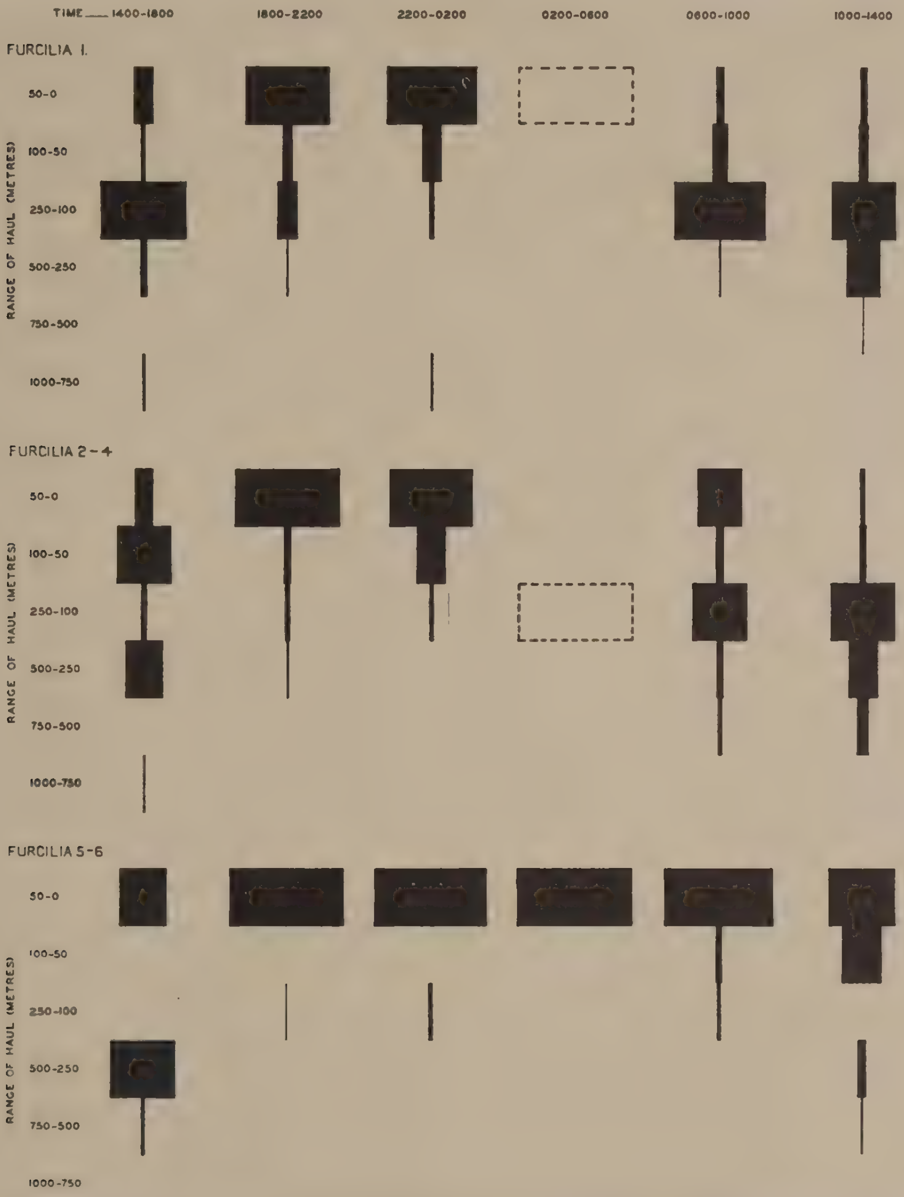

Fig. 73. Diagram showing diurnal vertical migration in Furcilia stages of *Euphausia superba*. The areas enclosed by broken lines indicate results obtained from inadequate data.

net, and to a greater extent the 750–500 m. net, yielded larvae, yet for all stages and whatever the time of day by far the greater majority was to be found in the four uppermost nets between 500 m. and the surface.

The first three diagrams indicate very clearly the pronounced diurnal migration that is to be found in the Calyptopis stages. It is to be noted that in the period which includes midday there are still larvae to be found in the uppermost net; in Calyptopis 2, for instance, 20 per cent of the total were found in this net. Even with such proportions, however, the three diagrams show that in the daylight hours the greater bulk of the larvae is away from the surface and below 100 m., while at night they are massed in the surface water above 100 m., with a marked concentration between 50 m. and the surface noticeable in Calyptopis 2 and 3. In the daytime the mass of the larvae are between 250 and 100 m., but the appreciable percentage in the 500–250 m. net indicates that the larvae are concentrated in the lower rather than the upper portion of the 150 m. traversed by the 250–100 m. net. If this is so it means that these larvae must migrate upwards through a distance of roughly 200–250 m. to get to the surface each night.

Mention has already been made (p. 121 *supra*) of the distribution of the larvae—Calyptopis 3 predominating—in the South Georgia plankton survey in January–February 1930. It will be recalled that all the larvae were taken in the stations made beyond the 250 m. contour and that the 500–250 m. net was the deep limit for the majority.

It seems likely that light intensity, rather than temperature or salinity, is the controlling factor in the vertical distribution of the larvae, for in their daily migrations the variation experienced by the larvae in the two latter factors is that to be found in the Antarctic surface water and the warm deep water. The absence of larvae in the shallow water in the neighbourhood of South Georgia seems to indicate that there is a necessity for the larvae to seek out greater depths, so that in the daytime they may recede to them in order to obtain that degree of light intensity which is most favourable for their existence.

In the two diagrams representing Furcilia 1 and Furcilia 2–4, the paucity of data for the period 0200–0600 upsets the evenness of the curve showing diurnal migration. Of Furcilia 1 for this period two larvae only were taken, and both were in the surface net: there was one larva of Furcilia 2–4 in the 250–100 m. net. It is probable that both groups of larvae, if they were adequately represented during this four-hour period, would have their greatest concentration between 250 and 100 m. On the whole the two diagrams show, although perhaps less clearly, the same diurnal migration as is witnessed in the Calyptopis stages.

There is a noticeable difference in the last of the six diagrams, that representing Furcilia 5 and 6, compared with the five preceding it. The larvae at all times of the day, with the exception of the 1400–1800 period, are concentrated in the two uppermost net hauls. The diurnal migration of earlier stages is not evident unless the distribution of the 1400–1800 period is indicative, but whether or not this is so, the diagram shows that in twenty out of the twenty-four hours the larvae are at the surface and that below 100 m.

the frequency of occurrence is comparable to the frequency below 500 m. in earlier larval stages.

In the section of this paper dealing with the circumpolar cruise it was shown that larvae of comparable stages of development to those last mentioned were almost invariably concentrated, whatever the time of day, in the upper of two oblique nets fished. This localized distribution was most marked in the results of the June visit to the ice-edge. John states that of two nets fished, one, 1 m. in diameter, towed at a depth of 2 m., caught large numbers of larvae, whereas the other, 70 cm. in diameter, towed at 5–7 m., caught none. The process was repeated with like results. This was in close proximity to pack-ice and in the daytime. Allowance has to be made for the superior catching power of the 1-m. net, but it is quite clear that the shoals of krill were limited vertically to a range of a few feet.

It has also been mentioned already (p. 149 *supra*) that, on the course taken by the 'Discovery II' from Bouvet to South Georgia in October–November 1930, when the ship was making its way along the edge of the pack, krill was almost always to be seen at the surface in great quantity, with larval and adolescent forms predominating.

VERTICAL DISTRIBUTION AT ST. 461

An extract from the scientific log referring to this station says:

> Seven hauls were made at intervals of four hours with a series of six 1-m. nets used obliquely. The oblique nets were put on the wire at intervals of 143 m. with 140 m. between the upper net and the surface. The total wire out was 855 m. The nets were hauled at 1½–2 knots and when the upper one had reached the surface the messenger was dispatched to close those below. Depths were determined by a depth gauge at the end of the wire and Kelvin tube near the second net from the top, the depths of the individual nets being calculated.... The first six hauls covering a period of twenty-four hours were taken without any hitch, but in the seventh haul one of the messengers failed to release on impact of that above and some nets were in consequence hauled open for longer than was intended.

The station was made in 56° 44′ S, 2° 23¾′ W to the south-west of Bouvet Island and in the vicinity of pack-ice. As might have been anticipated from the time of year, October 20–21, young *E. superba* were represented only by Furcilia 6 and small adolescents. It is noteworthy that while over eighteen and a half thousand young krill were taken in seven hauls, only 147 adults were found; of these 122 were in the *G* flight in the net fishing between 750 and 560 m. and closed at 315 m. The remaining adults were scattered throughout the nets of the other flights in number never more than four in any one net.

Table XL shows the quantities of young krill taken in the flights *A*–*G*. The depth of the nets and time of day are stated. The numbers show that a distinction can at once be made between the uppermost net catch of each flight and all the others. In five of the seven hauls relatively enormous quantities of krill were taken in the uppermost net, and in all seven more than 59 per cent of the total taken in each flight was in this net. In dealing with the numbers in the percentage column of the table, therefore, the figure given for the uppermost net is the percentage of the total caught in the flight of nets. For the remaining five nets the figures are the percentages of total number in those nets but excluding the first one. The vertical distribution is shown graphically in Fig. 74, the *G* haul being omitted. Although the young euphausians preponderated at the surface they were taken in appreciable numbers in the lowest nets, 660 in the sixth net of the *C* series being the greatest. When the station was started the ship was in shoals of krill which increased in density to a maximum at the time when the *C* flight was taken. The shoals had come to an end by the time the *E* and *F* hauls were made and another one was encountered at *G*.

Considering the lower nets, II–VI, it is seen that with the approach of night there is a distinct trend upwards of the main body of the larvae and a descent again in the morning. Thus in the *A* flight, between 2.30 and 3.0 p.m., the larvae are more or less evenly distributed below 100 m.: in the *B* flight between 6.30 and 7 p.m. they are concentrated between 500 and 400 m.: in the *C* flight between 10.30 and 11 p.m. they are concentrated between 400 and 300 m.: in the *D* flight between 2.30 and 3.0 a.m. the subsurface krill has merged with the main body of the surface shoal, and in *E*, with the approach of daylight, there is a withdrawal of some of the krill from the surface to an ill-defined point of concentration at about 300 m.

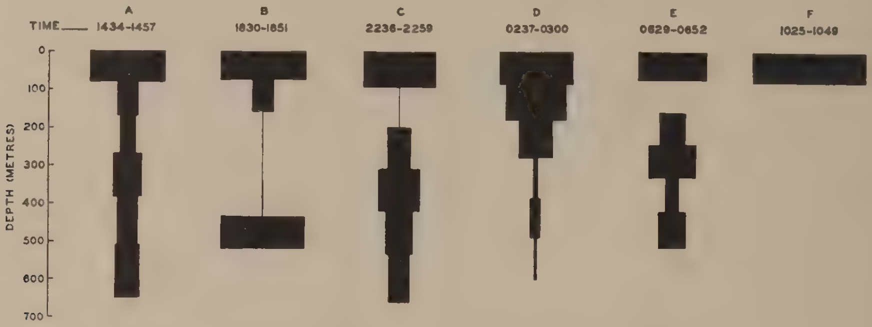

Fig. 74. Vertical distribution of young *Euphausia superba* at St. 461.

To what are we to attribute this difference of behaviour in the larvae dividing them into the two groups, (*a*) those that remain at the surface and (*b*) those that undergo a vertical diurnal migration? There are several possible factors which might be effective, of which the following may be considered:

(i) Differences due to ontogenetic variation in the two groups.
(ii) Hydrographic differences.
(iii) Seasonal changes.

(i) As Russell (1927, p. 239) points out, a species may be found to occur at a certain depth when adult, but while young it may have a different vertical distribution. Examination of the larvae from St. 461 shows that no distinction can be made between the degree of development of the surface larvae and those taken deeper down; they are a homogeneous population with Furcilia 6 and adolescents occurring in all the catches in proportions which preclude any conclusion that either stage prefers a particular water depth (see Appendix II).

(ii) There is a well-marked discontinuity below 100 m. where the cold surface water and the intermediate warm water meet. It might be suggested that this is the barrier which concentrates so large a proportion of the larvae at the surface, but examination of Table XL shows that it is apparently not a sufficiently strong obstacle to prevent the migration of the subsurface larvae which move towards, and actually merge with, the surface group in the *D* series. In this series the discontinuity is at 230 m.

Table XL. *Catches of young* Euphausia superba *at St.* 461

Haul ...	*A*			*B*			*C*			*D*		
Time ...	1434–1457			1830–1851			2236–2259			0237–0300		
Net	Depth	Number	Percentage	Depth	Number	Percentage	Depth	Number	Percentage	Depth	Number	Percentage
I	80–0	1450	62	75–0	2800	76	95–0	4180	64	85–0	1000	69·6
II	170–80	148	19·5	160–75	172	19·5	200–95	7	0·3	180–85	232	53
III	270–170	109	14·5	255–160	18	2	310–200	483	20·5	280–180	136	31·1
IV	385–270	193	25·4	345–255	5	0·6	420–310	864	36·7	385–280	18	4·1
V	510–385	143	18·8	440–345	27	3·1	535–420	565	24	490–385	41	9·4
VI	650–510	166	21·9	520–440	660	74·8	660–535	435	18·5	600–490	10	2·3
Total	2209			3682			6534			1437		

Table XL (*cont.*)

Haul ...	*E*			*F*			*G*		
Time ...	0629–0652			1025–1049			1429–1458		
Net	Depth	Number	Percentage	Depth	Number	Percentage	Depth	Number	Percentage
I	75–0	25	59·5	80–0	13	100	95–0	3584	100
II	160–75	—	—	175–80	—	—		Lower nets fouled	
III	245–160	4	23·5	270–175	—	—			
IV	330–245	7	41·1	375–270	—	—			
V	420–330	2	11·8	490–375	—	—			
VI	515–420	4	23·6	615–490	—	—			
Total	42			13			3584		
Grand total 17,501									

For the first net of each flight the percentage stated is of the total number in all six nets, for the remaining five nets the percentage is of the total number of individuals in those nets.

With the exception of the rather small numbers of Furcilia 5 and 6 in the 70-cm. vertical nets, the catches at St. 461 provide the only direct indication we have of vertical distribution in the later stages of development. Yet if the younger larval stages are not susceptible to the changes resulting from a vertical migration from warm to cold water and *vice versa*, it is unlikely that the older larvae would react more readily. It has been shown above that the younger larvae migrate upwards from depths greater than 250 m., involving passage from the intermediate warm water to the colder surface water. The eurythermal and euryhaline qualities of *E. superba* are fairly high, and it is considered that the presence of a discontinuity like that at St. 461 is not adequate to explain the preference of the bulk of the animals for the surface.

(iii) I feel compelled to select the third as the most important factor in the distribution of the larvae. It has been shown above that the younger larvae from Calyptopis 1 onwards have a quite well-defined diurnal vertical migration. In the last of the diagrams in Fig. 73 it was shown that the vertical migration is not pronounced and that the animals tended to remain at the surface whatever the time of day. Examination of the time of year when the larvae were taken, from which that diagram was derived, shows that about nine-tenths of the total were taken early in their second season—that is to say after the southern winter.

The winter and all it implies is, I am sure, the factor which leads to interruption of the rhythmic migrations of the euphausians. Prolonged darkness, overcast skies, low altitude of the sun and consequent increased reflection of its rays from the surface of the sea, snow falling in the very cold water and hardly melting, but predominantly the presence of pack-ice, all render it less necessary for the larvae to seek out the deeper water in daytime.

This influence of ice has been previously recognized. Russell (*loc. cit.*, p. 231) mentions the researches of Damas and Koefoed (1907) into the distribution of copepods in the Greenland Sea. They observed changes in the depth distribution according to region. "They found that species of the intermediate and deep layers were met with in the ice covered western part of the Greenland Sea at much higher levels than in the eastern uncovered portion. They further, on an examination of the hydrographic data, concluded that this difference was not occasioned by currents and had no relation with salinity or temperature."

Damas and Koefoed indicate that the light intensity is the important factor.

Römer (1904, p. 72), cited in the same paper by Russell (p. 256) states: "In the warmer ice-free waters of the west coast (of Spitzbergen) the difference between the scarceness of plankton in the surface layers in the daytime and its abundance in the evening and at night is much more marked than below the thick pack-ice of the eastern region. It is most probable that this is due to the strong cutting off of the light rays by the ice." It is likely that similar conditions produce like results in *E. superba* and explain the abundance in which it is found in the vicinity of ice fields.

In addition, however, to pack-ice affecting light intensity there is another way in which it probably helps in the formation of shoals of krill. If we assume that in ice-free water, before the coming of the cold conditions of winter, the larval krill is more or less evenly distributed, or even if it is in small swarms of individuals which have developed from the same brood, in its migrations upwards to the surface it will be fairly evenly distributed in the surface water. But when pancake-ice is formed and, later, pack-ice, the cutting off of the light rays necessary for photosynthetic processes will diminish the production of diatoms underneath the ice and there will be a movement of the krill to areas of greater abundance of food at the periphery of the ice-field. That this happens is proved by observations on the circumpolar cruise and the voyage which the 'William Scoresby' made into the Weddell Sea (see pp. 137, 148). The latter instance is most striking because the ship penetrated far into an area which is normally ice-covered for the greater part of the year, and the stations where krill was taken are all concentrated on the northern part of the line between South Georgia and the point east of the South Sandwich Group, where the ship turned southwards into the water of the eastern Weddell Sea. No krill was taken in the part of the Weddell Sea which is normally ice-covered, although the observations included a station at the ice-edge with hauls throughout a twenty-four-hour period (St. WS 552). It cannot be doubted that krill does not penetrate far beyond the edge of the ice-field, and that to some extent at any rate the concentrations met with in the vicinity of the pack are caused by the movement, towards the periphery of the pack, of krill which was more uniformly distributed before the formation of the ice-field.

An explanation is required however to account for the persistence of some of the krill in a vertical migration towards the surface at night. Russell (1927, p. 235), quoting Michael's results (1911, p. 144) of investigations into the vertical distribution of certain Chaetognatha, states:

> All individuals do not react towards light, temperature and salinity in the same way. While the majority migrate towards the surface during twilight hours and toward deeper water during intense light and darkness, a few almost always remain in deeper water during twilight and on the surface during intense light and darkness. Similar individual differences occur with respect to temperature and salinity. This means that those optimum conditions favourable to the species as a whole are not favourable to each individual or in other words the characteristic organization, constitution or physiological state of each individual modifies the effect of light, temperature and salinity on its behaviour.

The principle involved in the foregoing quotation can be applied to *E. superba*, although there is a modification in behaviour. At the time of year we are considering the optimum conditions for the greater part of the krill are at the surface, but for the rest they are at a variable distance from the surface dependent on the time of day. Now it has already been pointed out that, even in the Calyptopis stages where there is a pronounced diurnal migration, there are still appreciable numbers of larvae to be found at the surface at midday. In the later larvae with which we are dealing the predilection for the surface has become emphasized. To this extent the difference in distribution may be ontogenetic in origin, simply because the time of year when Furcilia 6 and adolescents are predominant coincides with the period of winter conditions and concomitant alteration in light intensity.

It may be that at St. 461 the animals which undergo a diurnal vertical migration are still influenced by light intensity to a greater extent than those remaining at the surface, or it may be that their movements indicate the last vestiges of a physiological rhythm acquired in earlier larval history and persisting when the stimulus which originally promoted it is no longer active. This may be so, but the important fact is that with adolescence there is an abandonment of diurnal migration, and whereas the majority of the larvae from Calyptopis 1 to Furcilia 5 undergo a rhythmic alteration in vertical position the adolescents are persistently at the surface.

The significance of this distribution is that it affects the distribution of krill in the Antarctic, but before dealing with this the general water movements within the Antarctic should be recalled. Deacon (1933, p. 226 *et seq.*) states:

> The movement of Antarctic surface water away from the Antarctic regions towards the north is known to take place all round the Pole and it is also known that there is a similar movement of Antarctic bottom water towards the north near the sea-bottom. To make up for this transport of water away from the Antarctic regions in the surface and bottom layers there must be a movement towards the Pole in the intermediate layer. This is supplied by a movement southwards in the warm deep layer....There can be no doubt that the water at the level of maximum temperature in the Antarctic Zone has a component of movement southwards.

Again on p. 173:

> In the Antarctic Zone the surface layer is composed of cold poorly saline water which lies in a shallow well-defined layer above warmer deep water. It has a depth of 100–250 m.

The discontinuity is shallower in the south than in the north. The observed occurrence of *E. superba* in this system of currents having components of direction opposed to one another is worth considering. It has been shown that eggs, Nauplii and Metanauplii are taken in greatest abundance in the deeper water, their component of movement will therefore be southwards. Calyptopis and early Furcilia have a diurnal vertical migration which brings them into the north-flowing surface water during the hours of darkness but which returns them to the south-flowing deep water in the daytime. Their component of movement will therefore be dependent on the time spent in each water layer each day and on the rates of movement of the two water-masses. The accumulation of late Furcilia and adolescents at the ice-edge would suggest that the resultant direction of movement of the larvae is generally in a southerly direction. The late Furcilia and adolescents, as we have just shown, are surface-loving in their habit, and they will be borne northwards in the surface water of the Antarctic streaming away from the Pole. The distribution of adults does not come within the scope of this paper, but it may be anticipated that they would be found more generally distributed between the Antarctic convergence and the ice-edge than are the adolescents. For instance, at St. 461 in the *A* flight of nets there were 9220 Furcilia and adolescents, but only 2 adults; in the *B* flight 3682 Furcilia and adolescents, with 4 adults; for *C* the figures are 6534 and 10, for *D* 1437 and 9, for *E* 42 and none, for *F* 13 and none, and for *G* 3584 and 122. There is no indication at this station of adult krill in quantity in any way indicative of the vast shoals which occur elsewhere. Again at the stations succeeding 461 along the ice-edge, although adults certainly were taken they nowhere occurred in quantity approaching that in which larvae and adolescents were found.

TIME DISTRIBUTION

In Fig. 75 is shown the range in time of the different stages of development. The time ranges for the occurrence of eggs, Nauplii and Metanauplius have already been discussed, but they have been inserted in the diagram to show them in relation to later stages. For each stage represented in the diagram there are six horizontal divisions indicating the six seasons from which data have been obtained: thus the lowest division represents the season 1926–7 and the uppermost the season 1931–2. For most of the seasons observations ended with the end of the southern summer, and for the months of May to mid-August the records of the occurrence of young krill are entirely derived from the circumpolar cruise collections. It is for this reason that there is an apparent abrupt termination in the occurrence of Metanauplius, Calyptopis and Furcilia 1 and 2. The continuous line indicates half-months in which larvae were found; the dotted lines

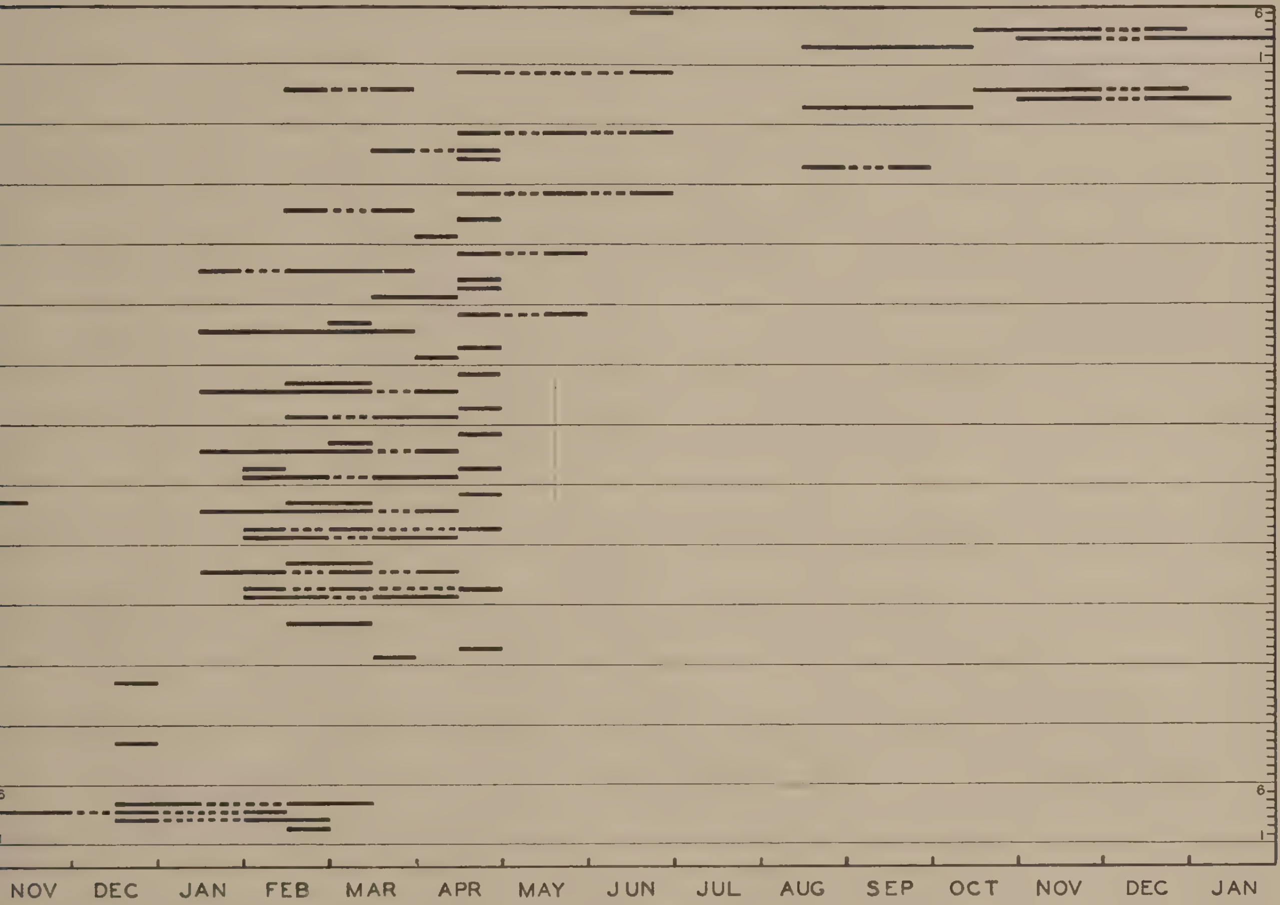

Fig. 75. Seasonal distribution of developmental stages of *Euphausia superba*.

connecting continuous lines are intervening periods between half-months in which larvae were found, and during which periods it may be assumed that they would be likely to occur.

The figure shows that from the second half of January onwards to the end of April at any rate, stages from Calyptopis 1 to Furcilia 1 are to be found. There is a single record of a Calyptopis 2 in the first half of November which, I consider, must be regarded as an exception. There is no general incidence of early larvae until the second half of January, and their absence in the May observations of the circumpolar cruise indicates that the stages up to Furcilia 1 are passed through before the coming of winter conditions. Furcilia 2 and 3, like earlier stages, occur in the second half of January and are the youngest forms found in May; their time range is therefore four and a half months. The first records of Furcilia 4 and 6 are not obtained until the second half of February. Furcilia 5 has no record before the second half of March, but it must, of course, occur at a time preceding the first occurrence of the ensuing stage. Furcilia 4 is found in June, so that like Furcilia 2 and 3 it has a time range of four and a half months but with its first record a month later than the previous stages.

Furcilia 5 has a considerably longer time range of occurrence, for from March onwards it is found until the end of the southern winter in September. It should be pointed out, however, that Furcilia 5 occurs only in extremely small numbers in the August-September catches (see Appendix I, Sts. WS 259, 261–263, 266, 268 and 286). Furcilia 6 has by far the greatest period of occurrence. The first record is in the latter half of February and the last in the first half of January, a period of eleven months; but from November to January (see Appendix), where numbers in the samples are large enough to give a reliable indication, Furcilia 6 is a very small and insignificant constituent of the krill population.

In the diagram the occurrence of adolescents is traced from the first record in June to the time in January when the euphausian becomes of such a size that determination of the state of maturity and distinction from the previous year class is an anatomical problem not to be dealt with here.

The extended period during which Furcilia 6 is represented is in part due to the intervention of winter, during which growth is retarded and developmental processes slowed down. But there is no doubt that the extended period of occurrence is to some extent apparent rather than real. There is no clear line of demarcation between Furcilia 6 and adolescent; the character used to recognize the former stage, namely the presence of three postero-lateral spines and one terminal spine on the telson, is one which can be possessed by larvae within a very wide range of size. If, as is the case, it is possible for *E. superba* to be sexually mature while still lacking its full structural development, it is quite likely that forms recognized as Furcilia 6 may in fact be more properly classed as adolescent. In time distribution, as in development, later stages become less capable of narrow definition. The significant point ecologically is that this extension of the time occurrence of well-advanced krill ensures a constant food supply for the whales in Antarctic waters.

GENERAL REMARKS ON DISTRIBUTION

Notwithstanding the fact that the records of the occurrence of eggs indicate that *E. superba* prefers the far south for spawning, the place where eggs were taken differs widely from those where Metanauplii and Calyptopis 1 were taken. It is felt that concentrations of eggs, which were found in the Bransfield Strait, almost to the exclusion of other localities, must be due to the peculiar hydrographic and bathymetric in that region. The distribution of Metanauplius and Calyptopis 1 (Figs. 32, 76) indicates that these forms have no immediate relation to the occurrence of pack-ice nor are they restricted to the southern parts of the Antarctic. In the west of the Scotia Sea Metanauplii extend to the north almost to the Antarctic convergence. To the east, westward of South Georgia, at St. WS 197 where 115 were taken, they are found at a time of year, the second half of April, when ice is far to the southward. Similarly Calyptopis 1 is so scattered in its distribution that no correlation with pack-ice can be obtained. The time between the laying of eggs and their development into Calyptopis 1 is assumed to be comparatively short, so that the distribution of stages up to this point should be approximately the same as that of the spawning adults. When the larva reaches Calyptopis 1 the vertical migration already noted in this and subsequent stages will affect the regional distribution.

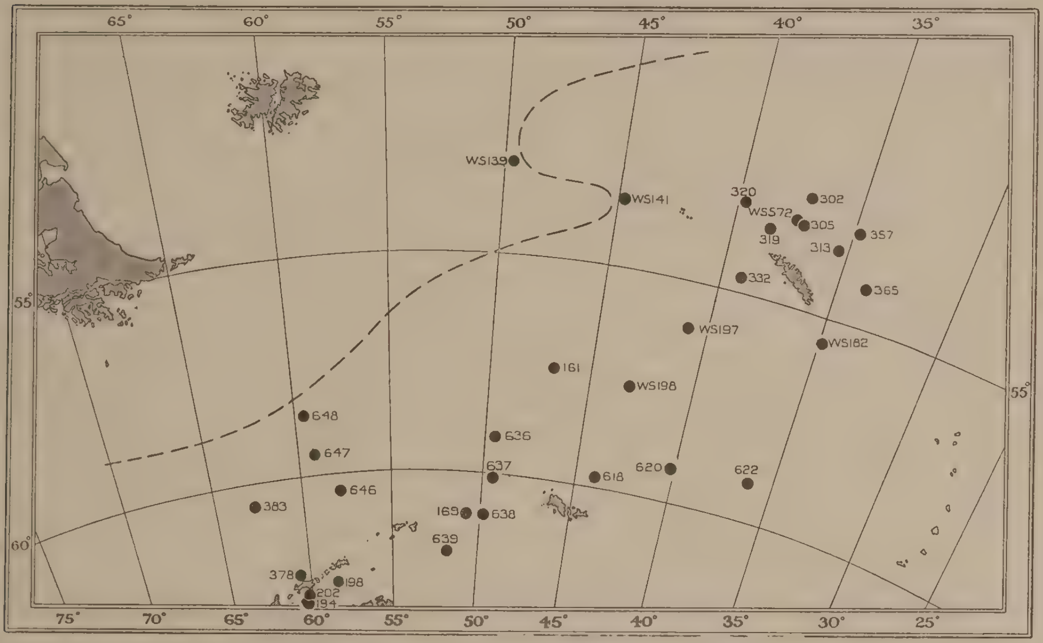

Fig. 76. Distribution of *Euphausia superba*, 1st Calyptopis.

If spawning took place at the surface in proximity to ice we would expect to find that increasing advancement of development in the larvae would be correlated with increasing distance from the regions where pack-ice is abundant, but nothing of this nature is shown in the material examined. Investigation of the adults and the occurrence of gravid females should indicate whether there is a concentration of the latter in the region of pack-ice. The few records of gravid females in the present material show that some were taken off the coast of South Georgia (St. 356), some in the Bransfield Strait (St. 548), some off the Biscoe Islands (St. 602), and some at a point about midway between South Georgia and the South Orkneys (St. WS 376). Although the records are admittedly small, yet such as exist are very widely scattered and give no indication of concentration in any particular locality.

The scarcity of adult *E. superba* as compared with adolescents along the edge of the pack, demonstrated by the catches in the line of stations from Bouvet westwards to South Georgia and in the South Georgia survey succeeding it in October–November 1930 (p. 149), shows that it is not at the ice-edge that one would expect to find them. The numbers for the stations instanced are as follows: adults 869; adolescents, including Furcilia 6, 195,164. The scarcity of adult *E. superba* at the ice-edge stations of the circumpolar cruise has been noted by John. The ice-edge is predominantly and almost exclusively the locus of adolescent krill and not of adult krill, at any rate at this time of year just prior to that when spawning is believed to commence.

It has been shown that this adolescent krill stays in the surface water which is moving away from the Pole, so that it will be borne northwards in the Antarctic surface water towards the Antarctic convergence.

It may be noted here that the whalers speak of Blue whale krill and Fin whale krill to describe respectively adolescent and adult *E. superba*. Ruud (1932, p. 46) says:

> There seems.....to be an undoubted correlation on the one hand of abundant drift ice with abundant Blue whales and krill of Group I [i.e. adolescents] and on the other hand of a small quantity of drift ice with abundant Fin whales and krill of Group II [i.e. adults].
>
> If *E. superba* spawns under and near the drift ice its spawning ground is the zone of the pack ice and as a rule the conditions off South Georgia are not suitable for its spawning. The stock of krill at South Georgia must therefore be carried thither by the current in the Antarctic surface layer. When the newly hatched larvae drift out of the Weddell Sea with the ice they gradually develop and grow in conformity with the curve of growth with which we are familiar. Group I may be found comparatively far from the actual spawning ground but still near the ice; farther away, near the extreme limits of the distribution of *E. superba* and at a distance from the ice there will be only Group II. When there is little ice at South Georgia we only find Group II but with a great deal of ice there is also a large proportion of Group I. The Blue whale is a more typical ice whale than the Finner, hence the correlation of abundant ice, krill of Group I and Blue whales—and of a small quantity of ice, krill of Group II and an abundance of Fin whales.
>
> Owing to the rotatory motion of the surface current in the Weddell Sea and other parts of the Antarctic, the central spawning ground of the krill in the drift ice zone will always be supplied with an ample stock of animals of Group II—sufficient to produce a large stock of larvae when they spawn.

In the light of the present data, it is necessary to make some modification in the conception of the mechanism by which the return of the krill to the south is brought about.

The hydrological evidence of a complete rotatory surface movement in the horizontal plane is very scanty. One would expect that a well-defined and constantly flowing current southwards would be required to bring about the replenishment of *E. superba* necessary to ensure a continuance of the abundance in which it is found in Antarctic waters. Deacon (1936, p. 19) says:

> The movement towards the west, the northward current along the east coast of Graham Land, and the current flowing out of the Weddell Sea towards the east, form three parts of a cyclonic movement which extends across the entire width of the Atlantic Ocean. The surface temperature distribution suggests that the cyclonic movement may be completed by a southward movement between 20° and 30° E; there is, however, very little evidence of such a current at the surface, although its existence in the warm deep layer cannot be doubted.

Ruud's scheme does not take into account the predominance of eggs and Metanauplius in the region of the warm deep water, which has a component of direction southwards, not northwards, neither do his data give information about diurnal migration in the Calyptopis and early Furcilia stages. Two items of negative evidence should also be considered—the great scarcity of adult krill at the ice-edge at the beginning of the summer season and the lack of eggs in the proximity of field-ice in number in any way approaching that obtained, for instance, at St. 540. The fact that krill does not occur far inwards from the peripheral region of field-ice is also important.

The present results suggest that replenishment of the stock of krill is assured by a rotary movement involving the northward flowing surface water, the southward-flowing deep water and the distribution and migrations of krill within these currents.

The accumulation of adolescents at the ice-edge can then be accounted for by suggesting that the resultant direction of movement in the eggs and in Metanauplius to early Furcilia stages has a southerly component. The periphery of the ice-field is the southern limit for the larvae, where they will tend to be massed together. This shoaling is probably assisted also by the increase in area of the ice-field with the advent of winter conditions and the freezing of the sea, leading to a further accumulation at the ice-edge of larvae which were formerly in ice-free water.

The habitat of the late Furcilia and early adolescents is at the surface and predominantly at the ice-edge. They will spread northwards in the northerly flowing surface water, with the breaking up and drifting away of the field-ice in the spring and summer. The adults, as Ruud points out, will be found at a distance from the ice. From the records of the deep occurrence of eggs and early larval stages it is considered more probable that they, rather than the adults returned to the south by the rotary motion of the surface currents, are responsible for the replenishment of the stock of adolescents at the ice-edge.

The absence of adult krill in any abundance at the ice-edge, at a time just prior to that when spawning is supposed to commence, negatives the assumption that they are brought back to the drift-ice zone by rotary motion of the surface currents. At any rate, if it is admitted that adolescents are predominantly at the surface and if this position is maintained until the adult state is reached, it means that for about a year they are in water which has a resultant component of direction northwards. In such a period of time they would be carried far away from the ice-edge towards the Antarctic convergence.

SUMMARY

1. The egg, Nauplius, Metanauplius and Calyptopis stages of *Euphausia superba* have been described—Nauplius 2 for the first time (p. 17).

2. The nature of Furcilia stages in Euphausiacea has been discussed. The suggestion is advanced that, in the light of the data supplied by the present material and the interpretation of known larval histories in conjunction with these results, the actual number of stages in early Furcilia development is much smaller than previously acknowledged (p. 32).

3. A division is made of larvae with all pleopods setose and seven terminal spines on the telson into two Furcilia stages: (*a*) those that on moulting are again seven-spined, (*b*) those that on moulting are five-spined (p. 41).

4. Reasons are given for abandoning the term Cyrtopia (p. 50).

5. Later larval development is diffuse and ill-defined and individual variation is great (p. 51).

6. Anatomical descriptions of Furcilia stages are given to indicate the general trend of development (p. 68).

7. The term adolescent as used in this report is defined and the indistinctness of this phase emphasized (p. 99).

8. Anomalous length frequencies are discussed and reasons suggested why some of the larvae in their second season are so much larger than the majority. A correlation between large size and phytoplankton distribution is given, but doubt is expressed whether the correlation is a direct one or due to a community of conditions affecting phytoplankton in abundance and euphausians in length (p. 103).

9. The average lengths of earlier larvae indicate that the young euphausian reaches a length of about 10 mm. by the end of its first summer season (p. 106).

10. In the first year or fourteen months *E. superba* reaches a length of over 24 mm. Growth is not regular, being slowed down during the winter months (p. 107).

11. The distribution of eggs, Nauplii and Metanauplius shows that these stages are found in deep rather than shallow water. Regionally the majority of the eggs have been found in the Bransfield Strait, but Metanauplii are widely spread throughout the Scotia Sea. The second half of the summer season is the time when eggs, Nauplii and Metanauplius are to be found (p. 109).

12. The distribution of Calyptopis and Furcilia stages is described, and the general impression obtained is that in the Falkland sector at any rate no well-defined predilection for the immediate vicinity of ice can be demonstrated (p. 117).

13. The ice-edge distribution of Furcilia 6 and adolescents is made clear, especially by the results obtained from the circumpolar cruise stations and a line of stations from Bouvet to South Georgia early in the summer season (p. 137).

14. The vertical distribution and migrations of young *E. superba* are described and the distinction made between early stages which have a well-defined diurnal vertical migration and the adolescents which remain continuously at the surface (p. 151).

15. The time distribution of larvae and adolescents shows that with advancing development there is a lengthening of time of occurrence. This is another way of expressing the increasingly indefinite nature of the process of development. The wide range of time within which older forms are found is important ecologically as it ensures a constant supply of food for the whalebone whales in the south. Eggs are found over a period of four and a half months in the earlier part of the southern summer season. Calyptopis and early Furcilia predominate from January onwards and are not found at the beginning of the next summer season. Later Furcilia forms are prominent in the second half of the summer season and a few are found after the winter. Furcilia 6 originates, generally speaking, late in the summer season and has an extended period of occurrence carrying it midway into the summer season following hatching. Adolescents have a still more extended period of occurrence, the complete range of which is not within the scope of the present paper (p. 161).

16. It is postulated that in the light of the information obtained concerning

(*a*) Deep distribution of eggs, Nauplii and Metanauplius,

(*b*) Diurnal migration of Calyptopis and early Furcilia in warm deep water and Antarctic surface water,

(*c*) Persistent occurrence of adolescents at the surface,

that the continued abundance of *E. superba* in Antarctic waters and the replenishment of the stock of adolescents at the ice-edge is brought about by the rotary movement resulting from the assemblage of the earlier developmental stages chiefly in the southward flowing warm deep water and that of the later stages in the northward flowing Antarctic surface water. This movement is suggested as an alternative to the hypothesis which involves the return of adults to the ice-edge by rotary movements in the surface water alone (p. 163).

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APPENDIX I

Length frequencies and average lengths of late Furcilia forms and early adolescents taken in the 1-m. nets

Station ... Date ...	WS 254 22. viii. 28			WS 255 22–23. viii. 28			WS 256 23–24. viii. 28			WS 257 27. viii. 28			WS 258 27. viii. 28			WS 259 27–28. viii. 28			
Length mm.	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 5	Furcilia 6	Adolescent	Total
6·5– 7·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1
7·0– 7·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
7·5– 8·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
8·0– 8·5	—	—	—	1	—	1	2	—	2	—	—	—	—	—	—	—	1	—	1
8·5– 9·0	—	—	—	—	—	—	2	—	2	—	—	—	—	—	—	—	3	—	3
9·0– 9·5	—	—	—	—	—	—	5	—	5	—	—	—	—	—	—	—	3	—	3
9·5–10·0	—	—	—	1	—	1	6	—	6	—	—	—	—	—	—	—	3	—	3
10·0–10·5	—	—	—	—	—	—	4	—	4	1	—	1	1	—	1	—	3	—	3
10·5–11·0	1	—	1	1	—	1	4	—	4	—	—	—	1	—	1	—	4	1	5
11·0–11·5	1	—	1	—	—	—	—	—	—	—	—	—	1	—	1	—	2	1	3
11·5–12·0	2	2	4	—	—	—	—	1	1	—	—	—	1	—	1	—	2	2	4
12·0–12·5	1	2	3	—	—	—	—	—	—	—	—	—	1	—	1	—	—	—	—
12·5–13·0	—	1	1	—	—	—	1	1	2	—	—	—	—	1	1	—	—	—	—
13·0–13·5	—	1	1	—	—	—	—	2	2	—	—	—	—	—	—	—	—	—	—
13·5–14·0	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	1	1
14·0–14·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
14·5–15·0	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—
15·0–15·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	5	6	11	3	—	3	24	6	30	1	—	1	5	1	6	1	21	5	27
Percentage	45·5	54·5	—	100	—	—	80	20	—	100	—	—	83·3	16·7	—	3·7	77·7	18·5	—
Av. length, mm.	11·55	12·33	—	9·58	—	—	9·81	13·25	—	10·25	—	—	11·25	12·75	—	6·75	10·06	11·85	—
Gen. av., mm.	11·98			9·58			10·50			10·25			11·50			10·26			
Total in sample	12			3			30			1			6			112			

Station ... Date ...	WS 260 28. viii. 28			WS 261 28. viii. 28				WS 262 28. viii. 28			WS 263 28. viii. 28			WS 264 28. viii. 28			WS 265 29. viii. 28		
Length mm.	Furcilia 6	Adolescent	Total	Furcilia 5	Furcilia 6	Adolescent	Total	Furcilia 5	Furcilia 6	Total	Furcilia 5	Furcilia 6	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total
6·5– 7·0	—	—	—	—	—	—	—	1	—	1	—	—	—	—	—	—	—	—	—
7·0– 7·5	—	—	—	1	—	—	1	3	—	3	—	—	—	—	—	—	—	—	—
7·5– 8·0	—	—	—	—	—	—	—	—	—	—	1	—	1	—	—	—	—	—	—
8·0– 8·5	—	—	—	4	1	—	5	—	2	2	1	—	1	1	—	1	1	—	1
8·5– 9·0	2	—	2	1	5	—	6	—	3	3	3	—	3	4	—	4	1	—	1
9·0– 9·5	3	—	3	—	5	—	5	—	4	4	6	—	6	5	—	5	1	—	1
9·5–10·0	3	—	3	—	5	—	5	—	3	3	10	—	10	5	—	5	1	—	1
10·0–10·5	2	—	2	—	10	—	10	—	2	2	17	—	17	6	—	6	—	—	—
10·5–11·0	3	—	3	—	14	—	14	—	2	2	11	1	12	5	—	5	1	—	1
11·0–11·5	2	—	2	—	10	—	10	—	2	2	13	2	15	3	2	5	2	—	2
11·5–12·0	1	2	3	—	6	3	9	—	1	1	7	5	12	5	2	7	—	—	—
12·0–12·5	—	2	2	—	10	4	14	—	—	—	4	4	8	1	2	3	—	—	—
12·5–13·0	1	—	1	—	4	3	7	—	—	—	3	3	6	—	—	—	—	1	1
13·0–13·5	—	1	1	—	3	1	4	—	—	—	1	1	2	—	—	—	—	—	—
13·5–14·0	—	—	—	—	1	3	4	—	—	—	—	—	—	—	1	1	—	1	1
14·0–14·5	—	—	—	—	1	2	3	—	—	—	—	—	—	—	2	2	—	—	—
14·5–15·0	—	—	—	—	—	1	1	—	—	—	—	1	1	—	1	1	—	—	—
15·0–15·5	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—
15·5–16·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	17	5	22	6	75	18	99	4	19	23	77	17	94	35	10	45	7	2	9
Percentage	77·3	22·7	—	6·1	75·7	18·2	—	17·4	82·6	—	81·9	18·1	—	77·8	22·2	—	77·8	22·2	—
Av. length, mm.	10·25	12·25	—	8·16	10·99	13·08	—	7·13	9·75	—	10·61	12·19	—	10·24	12·75	—	9·89	13·25	—
Gen. av., mm.	10·70			11·2				9·29			10·89			10·79			10·64		
Total in sample	22			243				26			384			52			11		

Station ... Date ...	WS 266 29. viii. 28				WS 267 29. viii. 28			WS 268 29. viii. 28				WS 269 30. viii. 28			WS 270 30. viii. 28			WS 271 30. viii. 28	
Length mm.	Furcilia 5	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 5	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Total
7·0 7·5	—	—	—	—	2	—	2	1	—	—	1	—	—	—	—	—	—	—	—
7·5– 8·0	2	—	—	2	2	—	2	—	1	—	1	—	—	—	1	—	1	—	—
8·0– 8·5	—	2	—	2	8	—	8	—	3	—	3	—	—	—	1	—	1	—	—
8·5– 9·0	—	3	—	3	16	—	16	—	6	—	6	1	—	1	1	—	1	—	—
9·0– 9·5	—	6	—	6	17	—	17	—	8	—	8	—	—	—	—	—	—	—	—
9·5–10·0	—	4	—	4	13	—	13	—	7	—	7	—	—	—	—	—	—	1	1
10·0–10·5	—	6	—	6	8	—	8	—	8	—	8	1	1	2	2	—	2	—	—
10·5–11·0	—	7	1	8	5	1	6	—	6	—	6	—	1	1	1	—	1	1	1
11·0–11·5	—	—	—	—	5	1	6	—	3	—	3	—	—	—	—	—	—	—	—
11·5–12·0	—	2	1	3	2	2	4	—	3	4	7	—	1	1	2	—	2	—	—
12·0–12·5	—	—	1	1	1	3	4	—	2	5	7	—	2	2	—	—	—	—	—
12·5–13·0	—	—	3	3	—	2	2	—	—	1	1	—	2	2	—	1	1	—	—
13·0–13·5	—	—	1	1	—	3	3	—	—	1	1	—	—	—	—	1	1	—	—
13·5–14·0	—	—	5	5	—	3	3	—	—	—	—	—	—	—	—	—	—	—	—
14·0–14·5	—	—	4	4	—	2	2	—	—	—	—	—	—	—	—	—	—	—	—
14·5–15·0	—	—	3	3	—	2	2	—	—	—	—	—	—	—	—	—	—	—	—
15·0–15·5	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—
15·5–16·0	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
16·0–16·5	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—
Total	2	30	20	52	79	21	100	1	47	11	59	2	7	9	8	2	10	2	2
Percentage	3·8	57·7	38·5	—	79	21	—	1·6	79·6	18·6	—	22·2	77·7	—	80	20	—	100	—
Av. length, mm.	7·75	9·92	13·6	—	9·47	13·25	—	7·25	9·94	12·2	—	9·5	11·82	—	9·94	13·00	—	10·25	—
Gen. av., mm.	11·24				10·26			10·4				11·30			10·55			10·25	
Total in sample	113				120			70				12			11			3	

Station ... Date ...	WS 272 •30. viii. 28		WS 273 4. ix. 28		WS 274 4. ix. 28		WS 276 4. ix. 28			WS 278 12. ix. 28			WS 279 13. ix. 28			WS 280 17. ix. 28		
Length mm.	Furcilia 6	Total	Furcilia 6	Total	Furcilia 6	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total
7·5– 8·0	—	—	—	—	—	—	1	—	1	—	—	—	—	—	—	—	—	—
8·0– 8·5	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—
8·5– 9·0	—	—	—	—	—	—	1	—	1	—	—	—	1	—	1	1	—	1
9·0– 9·5	—	—	—	—	—	—	1	—	1	—	—	—	2	—	2	1	—	1
9·5–10·0	—	—	—	—	—	—	4	—	4	1	—	1	2	—	2	1	—	1
10·0–10·5	—	—	—	—	—	—	7	1	8	1	—	1	4	—	4	1	—	1
10·5–11·0	—	—	—	—	—	—	8	1	9	—	—	—	5	—	5	3	—	3
11·0–11·5	—	—	1	1	—	—	5	2	7	1	—	1	8	—	8	4	—	4
11·5–12·0	—	—	—	—	—	—	2	1	3	2	—	2	13	2	15	6	2	8
12·0–12·5	—	—	—	—	—	—	3	3	6	2	1	3	15	4	19	4	—	4
12·5–13·0	1	1	—	—	—	—	1	9	10	1	—	1	10	4	14	3	3	6
13·0–13·5	—	—	—	—	—	—	—	3	3	1	1	2	4	8	12	—	6	6
13·5–14·0	—	—	—	—	—	—	1	1	2	—	1	1	1	5	6	1	4	5
14·0–14·5	—	—	—	—	—	—	—	1	1	—	1	1	—	5	5	1	3	4
14·5–15·0	—	—	—	—	—	—	—	1	1	—	1	1	—	4	4	—	3	3
15·0–15·5	—	—	—	—	—	—	—	—	—	—	1	1	—	2	2	—	2	2
15·5–16·0	—	—	—	—	—	—	—	1	1	—	—	—	—	1	1	—	—	—
16·0–16·5	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	1	1
Total	1	1	1	1	1	1	34	25	59	9	6	15	65	35	100	26	24	50
Percentage	100	—	100	—	100	—	57·6	42·4	—	60	40	—	65	35	—	52	48	—
Av. length, mm.	12·75	—	11·25	—	8·25	—	10·46	12·85	—	11·69	13·92	—	11·73	13·55	—	10·5	13·75	—
Gen. av., mm.	12·75		11·25		8·25		11·47			12·58			12·37			12·06		
Total in sample	1		1		1		98			16			163			58		

Station … Date …	WS 281 17. ix. 28			WS 282 17. ix. 28			WS 283 17. ix. 28			WS 284 18. ix. 28			WS 285 18. ix. 28			WS 286 18. ix. 28			
Length mm.	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 5	Furcilia 6	Adolescent	Total
7·5– 8·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1
8·0– 8·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1
8·5– 9·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1
9·0– 9·5	—	—	—	—	—	—	—	—	—	—	—	—	2	—	2	—	2	—	2
9·5–10·0	—	—	—	—	—	—	—	—	—	—	—	—	3	—	3	—	4	—	4
10·0–10·5	—	—	—	2	—	2	—	—	—	—	—	—	7	—	7	—	8	—	8
10·5–11·0	—	—	—	1	—	1	2	—	2	—	—	—	9	1	10	—	7	—	7
11·0–11·5	—	—	—	2	—	2	4	—	4	—	—	—	12	3	15	—	11	—	11
11·5–12·0	4	—	4	5	—	5	5	1	6	—	—	—	9	5	14	—	7	—	7
12·0–12·5	6	—	6	3	1	4	4	—	4	2	—	2	9	5	14	—	7	7	14
12·5–13·0	3	2	5	4	2	6	4	4	8	—	—	—	8	6	14	—	5	4	9
13·0–13·5	1	1	2	6	2	8	3	4	7	—	—	—	1	6	7	—	3	7	10
13·5–14·0	1	4	5	5	4	9	2	12	14	—	—	—	—	9	9	—	1	10	11
14·0–14·5	—	4	4	2	10	12	1	9	10	—	—	—	—	4	4	—	1	5	6
14·5–15·0	—	5	5	2	12	14	—	11	11	—	—	—	—	1	1	—	—	5	5
15·0–15·5	—	2	2	1	11	12	—	10	10	—	—	—	—	—	—	—	—	3	3
15·5–16·0	—	1	1	—	9	9	—	9	9	—	—	—	—	—	—	—	—	—	—
16·0–16·5	—	—	—	—	4	4	—	8	8	—	1	1	—	—	—	—	—	—	—
16·5–17·0	—	—	—	—	3	3	—	2	2	—	—	—	—	—	—	—	—	—	—
17·0–17·5	—	—	—	—	6	6	—	4	4	—	—	—	—	—	—	—	—	—	—
17·5–18·0	—	—	—	—	1	1	—	1	1	—	—	—	—	—	—	—	—	—	—
18·0–18·5	—	—	—	—	2	2	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	15	19	34	33	67	100	25	75	100	2	1	3	60	40	100	2	57	41	100
Percentage	44·1	55·9	—	33	67	—	25	75	—	66·7	33·3	—	60	40	—	2	57	41	—
Av. length, mm.	12·52	14·25	—	12·78	15·24	—	12·27	14·88	—	12·25	16·25	—	11·38	12·9	—	8·0	11·35	13·6	—
Gen. av., mm.	13·43			14·43			14·23			13·58			11·99			12·2			
Total in sample	37			456			440			15			1600			900			

Station ... Date ...	WS 287 19. ix. 28			WS 288 19. ix. 28			WS 291 2. x. 28		WS 292 3. x. 28			WS 293 3. x. 28		WS 294 3. x. 28		WS 295 3–4. x. 28		
Length mm.	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Adolescent	Total	Furcilia 6	Adolescent	Total	Adolescent	Total	Adolescent	Total	Furcilia 6	Adolescent	Total
8·5– 9·0	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
9·0– 9·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
9·5–10·0	2	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
10·0–10·5	5	—	5	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—
10·5–11·0	3	—	3	3	—	3	—	—	—	—	—	—	—	—	—	—	—	—
11·0–11·5	13	1	14	5	—	5	—	—	—	—	—	—	—	—	—	—	—	—
11·5–12·0	16	5	21	10	2	12	—	—	1	—	1	—	—	—	—	—	—	—
12·0–12·5	10	6	16	10	2	12	—	—	1	—	1	—	—	—	—	—	—	—
12·5–13·0	7	11	18	7	8	15	—	—	—	—	—	—	—	—	—	1	—	1
13·0–13·5	3	10	13	4	9	13	—	—	—	—	—	—	—	—	—	1	—	1
13·5–14·0	—	6	6	2	12	14	—	—	—	—	—	—	—	1	1	1	1	2
14·0–14·5	—	2	2	1	8	9	1	1	—	—	—	—	—	1	1	1	3	4
14·5–15·0	—	1	1	1	7	8	—	—	—	1	1	—	—	1	1	1	8	9
15·0–15·5	—	—	—	—	5	5	—	—	—	—	—	—	—	1	1	—	10	10
15·5–16·0	—	—	—	—	2	2	—	—	—	—	—	—	—	2	2	—	14	14
16·0–16·5	—	—	—	—	1	1	—	—	—	1	1	—	—	3	3	—	13	13
16·5–17·0	—	—	—	—	—	—	—	—	—	1	1	—	—	7	7	—	14	14
17·0–17·5	—	—	—	—	—	—	—	—	—	—	—	—	—	2	2	—	11	11
17·5–18·0	—	—	—	—	—	—	—	—	—	—	—	1	1	3	3	—	14	14
18·0–18·5	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	4	4
18·5–19·0	—	—	—	—	—	—	—	—	—	—	—	—	—	2	2	—	—	—
19·0–19·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
19·5–20·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
20·0–20·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
20·5–21·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
21·0–21·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
21·5–22·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
Total	60	42	102	44	56	100	1	1	2	3	5	1	1	24	24	5	95	100
Percentage	58·8	41·2	—	44	56	—	100	—	40	60	—	100	—	100	—	5	95	—
Av. length, mm.	11·63	12·9	—	12·22	13·85	—	14·25	—	12·0	15·92	—	17·75	—	16·63	—	13·75	16·48	—
Gen. av., mm.	12·15			13·13			14·25		14·35			17·75		16·63		16·35		
Total in sample	108			20,440			1		5			1		24		412		

Station ... Date ...	WS 296 4. x. 28			WS 297 4. x. 28			WS 298 5. x. 28			WS 299 5. x. 28			WS 300 5. x. 28			WS 301 5. x. 28		
Length mm.	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total
10·0–10·5	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1	1	—	1
10·5–11·0	—	—	—	1	—	1	—	—	—	—	—	—	2	—	2	—	—	—
11·0–11·5	—	—	—	1	—	1	—	—	—	—	—	—	3	—	3	—	—	—
11·5–12·0	3	—	3	2	—	2	1	—	1	2	—	2	2	—	2	—	—	—
12·0–12·5	3	—	3	4	1	5	—	—	—	2	—	2	5	1	6	1	—	1
12·5–13·0	2	1	3	3	3	6	—	—	—	1	1	2	3	3	6	3	2	5
13·0–13·5	—	1	1	1	6	7	—	—	—	3	2	5	6	2	8	2	2	4
13·5–14·0	—	2	2	1	8	9	—	—	—	4	6	10	6	5	11	1	3	4
14·0–14·5	2	5	7	1	8	9	1	—	1	5	4	9	4	10	14	3	5	8
14·5–15·0	—	10	10	1	9	10	—	1	1	2	12	14	3	8	11	1	4	5
15·0–15·5	—	10	10	1	8	9	—	—	—	—	10	10	1	6	7	—	3	3
15·5–16·0	1	13	14	—	3	3	—	—	—	—	23	23	—	9	9	1	8	9
16·0–16·5	—	13	13	—	3	3	—	—	—	—	5	5	1	7	8	—	8	8
16·5–17·0	—	10	10	—	2	2	—	—	—	—	12	12	—	4	4	—	3	3
17·0–17·5	—	8	8	—	3	3	—	—	—	—	4	4	—	6	6	—	4	4
17·5–18·0	—	4	4	—	1	1	—	—	—	—	2	2	—	—	—	—	4	4
18·0–18·5	—	5	5	—	—	—	—	—	—	—	—	—	—	1	1	—	2	2
18·5–19·0	—	4	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
19·0–19·5	—	2	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
19·5–20·0	—	1	1	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—
Total	11	89	100	16	55	71	2	1	3	19	81	100	37	63	100	13	48	61
Percentage	11	89	—	22·5	77·5	—	66·7	33·3	—	19	81	—	37	63	—	21·3	78·7	—
Av. length, mm.	12·89	16·2	—	12·75	14·69	—	13·0	14·75	—	13·5	15·52	—	13·06	15·27	—	13·4	15·67	—
Gen. av., mm.	15·84			14·25			13·58			15·13			14·45			15·18		
Total in sample	344			78			3			332			368			61		

Station … Date …	WS 302 6. x. 28			WS 303 6. x. 28			WS 304 6. x. 28			WS 305 7. x. 28			WS 306 7. x. 28			WS 307 7. x. 28		
Length mm.	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total
9·5–10·0	—	—	—	—	—	—	1	—	1	—	—	—	1	—	1	—	—	—
10·0–10·5	—	—	—	1	—	1	4	—	4	3	—	3	3	—	3	—	—	—
10·5–11·0	—	—	—	2	—	2	6	—	6	4	—	4	4	—	4	1	—	1
11·0–11·5	—	—	—	2	—	2	6	—	6	2	—	2	3	—	3	1	—	1
11·5–12·0	1	—	1	5	—	5	8	1	9	12	—	12	6	1	7	1	—	1
12·0–12·5	4	—	4	5	1	6	9	2	11	18	1	19	8	6	14	—	—	—
12·5–13·0	4	—	4	10	3	13	15	2	17	11	11	22	5	5	10	3	2	5
13·0–13·5	7	7	14	6	7	13	7	5	12	8	5	13	3	9	12	2	1	3
13·5–14·0	6	8	14	3	12	15	7	7	14	2	7	9	2	3	5	—	2	2
14·0–14·5	3	14	17	2	7	9	4	4	8	2	5	7	1	2	3	—	2	2
14·5–15·0	2	14	16	—	4	4	1	5	6	—	5	5	—	2	2	—	2	2
15·0–15·5	—	9	9	—	2	2	—	3	3	—	2	2	—	—	—	—	1	1
15·5–16·0	—	6	6	—	2	2	—	2	2	—	2	2	—	—	—	—	1	1
16·0–16·5	—	7	7	—	2	2	—	1	1	—	—	—	—	—	—	—	—	—
16·5–17·0	—	4	4	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—
17·0–17·5	—	4	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
17·5–18·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
18·0–18·5	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	27	73	100	36	41	77	68	32	100	62	38	100	36	28	64	8	11	19
Percentage	27	73	—	46·7	53·3	—	68	32	—	62	38	—	56·3	43·7	—	42·1	57·9	—
Av. length, mm.	13·3	15·19	—	12·53	14·1	—	12·34	14·02	—	2·26	13·74	—	11·97	13·13	—	12·31	14·11	—
Gen. av., mm.	14·68			13·37			12·88			12·82			12·48			13·88		
Total in sample	129			88			232			404			70			20		

Station ... Date ...	WS 308 8. x. 28			WS 309 8. x. 28			WS 310 8. x. 28			WS 311 10. viii. 28		WS 468 9–10. xi. 29		WS 474 13. xi. 29			WS 476 14. xi. 29		
Length mm.	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Adolescent	Total	Furcilia 6	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total
9·5–10·0	—	—	—	—	—	—	1	—	1	—	—	—	—	—	—	—	—	—	—
10·0–10·5	—	—	—	—	—	—	1	—	1	—	—	—	—	—	—	—	1	—	1
10·5–11·0	1	—	1	1	—	1	2	—	2	—	—	—	—	—	—	—	—	—	—
11·0–11·5	—	—	—	—	—	—	3	—	3	—	—	—	—	—	—	—	—	—	—
11·5–12·0	—	—	—	—	—	—	4	—	4	—	—	—	—	—	—	—	—	—	—
12·0–12·5	—	1	1	—	—	—	5	4	9	—	—	—	—	1	—	1	—	—	—
12·5–13·0	1	—	1	—	—	—	6	1	7	—	—	—	—	1	—	1	—	—	—
13·0–13·5	—	2	2	—	1	1	1	3	4	—	—	—	—	—	—	—	—	1	1
13·5–14·0	—	3	3	—	—	—	—	4	4	—	—	1	1	—	—	—	—	1	1
14·0–14·5	—	1	1	—	—	—	—	7	7	—	—	—	—	—	—	—	—	—	—
14·5–15·0	—	1	1	—	—	—	—	6	6	—	—	—	—	—	—	—	—	—	—
15·0–15·5	—	—	—	—	—	—	—	3	3	—	—	—	—	—	—	—	—	—	—
15·5–16·0	—	—	—	—	—	—	—	3	3	—	—	—	—	—	1	1	—	—	—
16·0–16·5	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—
16·5–17·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
17·0–17·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
17·5–18·0	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—
18·0–18·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
18·5–19·0	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—
Total	2	8	10	1	1	2	23	33	56	1	1	1	1	2	1	3	1	2	3
Percentage	20	80	—	50	50	—	41·1	58·9	—	100	—	100	—	66·7	33·3	—	33·3	66·7	—
Av. length, mm.	11·50	13·63	—	10·75	13·25	—	11·88	14·3	—	18·75	—	13·75	—	12·50	15·75	—	10·25	13·50	—
Gen. av., mm.	13·2			12·00			13·3			18·75		13·75		13·58			12·42		
Total in sample	12			2			57			1		1		3			3		

Station ... Date ...	WS 477 14–15. xi. 29			WS 478 15. xi. 29		WS 480 16. xi. 29			WS 481 16. xi. 29			WS 482 16. xi. 29			WS 485 21. xi. 29		
Length mm.	Furcilia 6	Adolescent	Total	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total
10·5–11·0	1	—	1	—	—	1	—	1	—	—	—	—	—	—	—	—	—
11·0–11·5	—	—	—	—	—	—	—	—	1	—	1	—	—	—	1	—	1
11·5–12·0	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
12·0–12·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
12·5–13·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1
13·0–13·5	—	—	—	—	—	—	—	—	1	—	1	—	—	—	—	—	—
13·5–14·0	—	—	—	—	—	1	1	2	1	—	1	1	—	1	—	—	—
14·0–14·5	—	—	—	—	—	1	—	1	1	—	1	1	—	1	—	—	—
14·5–15·0	—	—	—	—	—	—	1	1	1	—	1	—	—	—	—	1	1
15·0–15·5	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—
15·5–16·0	—	—	—	—	—	—	—	—	—	1	1	2	—	2	—	—	—
16·0–16·5	—	—	—	—	—	—	2	2	—	—	—	1	1	2	—	1	1
16·5–17·0	—	—	—	1	1	—	2	2	—	—	—	—	—	—	—	1	1
17·0–17·5	—	1	1	—	—	—	—	—	—	1	1	—	—	—	—	—	—
17·5–18·0	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—
18·0–18·5	—	—	—	—	—	—	2	2	—	1	1	—	—	—	—	1	1
18·5–19·0	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—
19·0–19·5	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	2	2
19·5–20·0	—	—	—	—	—	—	1	1	—	1	1	—	—	—	—	1	1
20·0–20·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
20·5–21·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
21·0–21·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
21·5–22·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
22·0–22·5	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—
22·5–23·0	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—
Total	2	1	3	1	1	3	9	12	5	9	14	5	1	6	2	8	10
Percentage	66·7	33·3	—	100	—	25	75	—	35·7	64·3	—	83·3	16·7	—	20	80	—
Av. length, mm.	11·25	17·25	—	16·75	—	12·92	16·75	—	13·45	18·31	—	15·15	16·25	—	12·00	18·00	—
Gen. av., mm.	13·25			16·75		15·79			16·57			15·33			16·85		
Total in sample	3			2		14			14			6			11		

Length mm.	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescen	Total	Furcilia 6	Adolescen	Total	Furcilia 6	Adolescen	Total	Furcilia 6	Total	Furcilia 6	Adolescen	Total
10·0–10·5	—	—	—	—	—	—	1	—	1	—	—	—	—	—	—	—	—
10·5–11·0	1	—	1	—	—	—	1	—	1	—	—	—	—	—	1	—	1
11·0–11·5	—	—	—	—	—	—	2	—	2	—	—	—	—	—	—	—	—
11·5–12·0	1	—	1	—	—	—	1	—	1	—	—	—	—	—	—	—	—
12·0–12·5	—	—	—	1	—	1	7	—	7	—	—	—	1	1	—	—	—
12·5–13·0	3	—	3	2	—	2	8	—	8	2	—	2	—	—	—	—	—
13·0–13·5	—	—	—	—	1	1	3	—	3	—	—	—	—	—	—	—	—
13·5–14·0	1	2	3	1	1	2	2	—	2	1	—	1	—	—	—	—	—
14·0–14·5	2	3	5	1	—	1	2	—	2	1	—	1	—	—	—	—	—
14·5–15·0	2	3	5	—	2	2	1	1	2	—	—	—	—	—	—	1	1
15·0–15·5	2	4	6	—	3	3	1	2	3	—	1	1	—	—	—	—	—
15·5–16·0	1	8	9	1	6	7	—	2	2	—	1	1	—	—	—	—	—
16·0–16·5	—	11	11	—	9	9	—	1	1	—	—	—	—	—	—	—	—
16·5–17·0	—	11	11	1	11	12	1	—	1	—	—	—	—	—	—	—	—
17·0–17·5	—	8	8	—	16	16	—	2	2	—	—	—	—	—	—	—	—
17·5–18·0	—	6	6	—	9	9	—	—	—	—	—	—	—	—	—	—	—
18·0–18·5	—	6	6	—	7	7	—	—	—	—	—	—	—	—	—	—	—
18·5–19·0	—	1	1	—	7	7	—	—	—	—	—	—	—	—	—	—	—
19·0–19·5	—	5	5	—	7	7	—	—	—	—	—	—	—	—	—	—	—
19·5–20·0	—	4	4	—	4	4	—	—	—	—	—	—	—	—	—	—	—
20·0–20·5	—	3	3	—	5	5	—	—	—	—	—	—	—	—	—	1	1
20·5–21·0	—	2	2	—	2	2	—	—	—	—	—	—	—	—	—	—	—
21·0–21·5	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—
21·5–22·0	—	1	1	—	1	1	—	1	—	—	—	—	—	—	—	—	—
22·0–22·5	—	2	2	—	1	1	—	—	—	—	—	—	—	—	—	—	—
22·5–23·0	—	1	1	—	—	—	—	1	—	—	—	—	—	—	—	—	—
23·0–23·5	—	2	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—
23·5–24·0	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
24·0–24·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
24·5–25·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
25·0–25·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
25·5–26·0	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
26·0–26·5	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
26·5–27·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
27·0–27·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
27·5–28·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
28·0–28·5	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	13	87	100	7	93	100	30	10	40	4	2	6	1	1	1	2	3
Percentage	13	87	—	7	93	—	75	25	—	66·7	33·3	—	100	—	33·3	66·7	—
Av. length, mm.	13·75	17·86	—	14·04	17·67	—	12·85	17·3	—	13·38	15·50	—	12·25	—	10·75	17·50	—
Gen. av., mm.	17·33			17·42			13·96			14·08			12·25		15·25		
Total in sample	120			1424			45			15			1		3		

Station ... Date ...	WS 496 30. xii. 29			WS 497 1. i. 30		WS 498 2–3. i. 30		WS 499 3. i. 30			WS 501 3. i. 30		WS 508 10. ii. 30		WS 538 26. i. 31		WS 542 28. i. 31		WS 560 9. ii. 31	
Length mm.	Furcilia 6	Adolescent	Total	Adolescent	Total	Adolescent	Total	Furcilia 6	Adolescent	Total	Adolescent	Total	Adolescent	Total	Adolescent	Total	Adolescent	Total	Adolescent	Total
13·0–13·5	—	—	—	—	—	—	—	1	—	1	—	—	—	—	—	—	—	—	—	—
13·5–14·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
14·0–14·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
14·5–15·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
15·0–15·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
15·5–16·0	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
16·0–16·5	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
16·5–17·0	—	—	—	2	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
17·0–17·5	—	2	2	2	2	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—
17·5–18·0	—	1	1	1	1	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—
18·0–18·5	—	2	2	3	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
18·5–19·0	—	1	1	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—
19·0–19·5	—	2	2	1	1	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—
19·5–20·0	—	2	2	2	2	—	—	—	—	—	—	—	—	—	—	—	3	3	—	—
20·0–20·5	—	3	3	4	4	—	—	—	1	1	1	1	—	—	—	—	4	4	—	—
20·5–21·0	—	3	3	3	3	—	—	—	1	1	—	—	—	—	1	1	5	5	1	—
21·0–21·5	—	—	—	2	2	—	—	—	—	—	—	—	—	—	—	—	6	6	—	—
21·5–22·0	—	2	2	2	2	—	—	—	—	—	—	—	—	—	1	1	7	7	—	—
22·0–22·5	—	2	2	2	2	—	—	—	1	1	—	—	—	—	1	1	5	5	—	—
22·5–23·0	—	—	—	4	4	1	1	—	—	—	—	—	—	—	—	—	5	5	—	—
23·0–23·5	—	—	—	3	3	—	—	—	1	1	—	—	—	—	1	1	3	3	2	—
23·5–24·0	—	—	—	5	5	—	—	—	—	—	—	—	—	—	1	1	7	7	4	—
24·0–24·5	—	—	—	1	1	—	—	—	—	—	—	—	—	—	2	2	9	9	—	—
24·5–25·0	—	—	—	4	4	—	—	—	—	—	—	—	—	—	2	2	6	6	—	—
25·0–25·5	—	—	—	3	3	—	—	—	—	—	—	—	1	1	2	2	5	5	1	—
25·5–26·0	—	—	—	1	1	—	—	—	1	1	—	—	—	—	1	1	6	6	—	—
26·0–26·5	—	—	—	2	2	—	—	—	—	—	—	—	—	—	2	2	4	4	—	—
26·5–27·0	—	—	—	3	3	—	—	—	—	—	—	—	—	—	4	4	3	3	—	—
27·0–27·5	—	—	—	1	1	—	—	—	—	—	—	—	—	—	5	5	3	3	—	—
27·5–28·0	—	—	—	1	1	—	—	—	—	—	—	—	—	—	6	6	3	3	—	—
28·0–28·5	—	—	—	1	1	—	—	—	—	—	—	—	—	—	6	6	4	4	—	—
28·5–29·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6	6	1	1	—	—
29·0–29·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7	7	2	2	—	—
29·5–30·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5	5	—	—	—	—
30·0–30·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	9	9	2	2	—	—
30·5–31·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4	4	2	2	—	—
31·0–31·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4	4	—	—	—	—
31·5–32·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	3	1	1	—	—
32·0–32·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	3	1	1	—	—
32·5–33·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	2	—	—	—	—
33·0–33·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	2	—	—	—	—
33·5–34·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	2	1	1	—	—
34·0–34·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	2	—	—	—	—
34·5–35·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—
35·0–35·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
35·5–36·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—
Total	1	19	20	53	53	2	2	1	6	7	1	1	1	1	86	86	100	100	8	8
Percentage	5	95	—	100	—	100	—	14·3	85·7	—	100	—	100	—	100	—	100	—	100	—
Av. length, mm.	15·75	19·65	—	22·51	—	20·75	—	13·25	21·58	—	20·25	—	25·25	—	29·0	—	24·40	—	23·44	—
Gen. av., mm.	19·48			22·51		20·75		20·39			20·25		25·25		29·01		24·40		23·44	

Station ... Date ...	453 16–17. x. 30			454 17. x. 30			455 18. x. 30			459 19. x. 30			460 20. x. 30			462 23. x. 30		
Length mm.	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total
9·5–10·0	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1	—	—	—
10·0–10·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
10·5–11·0	—	—	—	—	—	—	—	—	—	2	—	2	—	—	—	—	—	—
11·0–11·5	—	—	—	—	—	—	—	—	—	1	—	1	1	—	1	—	—	—
11·5–12·0	—	—	—	3	—	3	2	—	2	—	—	—	1	—	1	1	—	1
12·0–12·5	1	—	1	2	—	2	4	—	4	1	2	3	1	—	1	1	1	2
12·5–13·0	1	2	3	—	—	—	2	—	2	3	1	4	1	1	2	—	3	3
13·0–13·5	1	2	3	2	2	4	2	1	3	—	9	9	—	2	2	1	2	3
13·5–14·0	—	3	3	—	3	3	1	6	7	1	9	10	—	2	2	1	8	9
14·0–14·5	—	5	5	—	1	1	1	10	11	3	9	12	1	7	8	—	11	11
14·5–15·0	1	5	6	—	5	5	—	11	11	—	10	10	—	6	6	—	17	17
15·0–15·5	—	9	9	—	9	9	1	12	13	—	10	10	—	8	8	—	10	10
15·5–16·0	—	4	4	—	14	14	—	14	14	—	11	11	—	4	4	—	20	20
16·0–16·5	—	2	2	—	18	18	—	11	11	—	8	8	—	2	2	—	9	9
16·5–17·0	—	8	8	—	15	15	—	4	4	—	6	6	—	3	3	—	7	7
17·0–17·5	—	3	3	—	10	10	—	5	5	—	6	6	—	2	2	—	4	4
17·5–18·0	—	3	3	—	8	8	—	7	7	—	4	4	—	1	1	—	3	3
18·0–18·5	—	—	—	—	4	4	—	2	2	—	1	1	—	1	1	—	1	1
18·5–19·0	—	—	—	—	3	3	—	1	1	—	2	2	—	—	—	—	—	—
19·0–19·5	—	—	—	—	1	1	—	2	2	—	—	—	—	—	—	—	—	—
19·5–20·0	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—
20·0–20·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
20·5–21·0	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—
Total	4	46	50	7	93	100	13	87	100	11	89	100	6	39	45	4	96	100
Percentage	8	92	—	7	93	—	13	87	—	11	89	—	14·5	85·5	—	4	96	—
Av. length, mm.	13·25	15·43	—	12·32	16·35	—	12·90	15·79	—	12·70	15·32	—	2·0	15·21	—	12·75	15·27	—
Gen. av., mm.	15·26			16·06			15·41			15·03			14·78			15·17		
Total in sample	870			210			6600			1036			47			490		

Station ... Date ...	463 25. x. 30			464 26. x. 30			465 26. x. 30			466 27. x. 30		467 28. x. 30			469 29. x. 30			470 30. x. 30		
Length mm.	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total
9·0– 9·5	—	—	—	—	—	—	—	—	—	—	—	2	—	2	—	—	—	—	—	—
9·5–10·0	—	—	—	—	—	—	—	—	—	—	—	3	—	3	—	—	—	2	—	2
10·0–10·5	1	—	1	—	—	—	—	—	—	—	—	8	—	8	6	—	6	2	—	2
10·5–11·0	1	—	1	—	—	—	1	—	1	—	—	7	—	7	3	—	3	1	—	1
11·0–11·5	1	—	1	1	—	1	1	—	1	—	—	10	—	10	5	—	5	—	—	—
11·5–12·0	—	—	—	3	—	3	2	—	2	—	—	6	—	6	2	—	2	2	—	2
12·0–12·5	1	—	1	2	—	2	2	—	2	—	—	3	1	4	2	—	2	—	—	—
12·5–13·0	1	1	2	3	—	3	3	1	4	—	—	4	1	5	8	2	10	2	—	2
13·0–13·5	—	1	1	2	1	3	5	2	7	—	—	2	4	6	5	5	10	1	—	1
13·5–14·0	—	2	2	1	4	5	3	4	7	—	—	—	6	6	—	4	4	—	—	—
14·0–14·5	—	—	—	9	4	13	2	6	8	—	—	3	5	8	1	3	4	—	—	—
14·5–15·0	—	8	8	—	9	9	—	5	5	1	1	—	8	8	1	7	8	—	—	—
15·0–15·5	—	7	7	1	7	8	—	4	4	—	—	1	1	2	1	11	12	—	—	—
15·5–16·0	—	4	4	—	12	12	—	2	2	1	1	—	3	3	—	7	7	—	1	1
16·0–16·5	—	6	6	—	10	10	—	2	2	—	—	—	4	4	—	7	7	—	2	2
16·5–17·0	—	5	5	—	12	12	—	1	1	—	—	—	4	4	—	12	12	—	—	—
17·0–17·5	—	4	4	—	4	4	—	2	2	—	—	—	—	—	—	5	5	—	—	—
17·5–18·0	—	2	2	—	6	6	—	2	2	1	1	—	2	2	—	2	2	—	—	—
18·0–18·5	—	2	2	—	5	5	—	1	1	—	—	—	1	1	—	5	5	—	—	—
18·5–19·0	—	—	—	—	3	3	—	—	—	—	—	—	1	1	—	—	—	—	—	—
19·0–19·5	—	1	1	—	3	3	—	—	—	—	—	—	2	2	—	2	2	—	—	—
19·5–20·0	—	—	—	—	—	—	—	—	—	—	—	—	4	4	—	1	1	—	—	—
20·0–20·5	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	2	2	—	—	—
20·5–21·0	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
21·0–21·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
21·5–22·0	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—
22·0–22·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—
Total	5	43	48	22	81	103	19	33	52	3	3	49	48	97	34	76	110	10	3	13
Percentage	10	90	—	21	79	—	36·5	63·5	—	100	—	50·5	49·5	—	30·9	69·1	—	76·9	23·1	—
Av. length, mm.	11·45	15·88	—	13·31	16·28	—	12·85	15·26	—	16·08	—	11·43	15·75	—	12·07	16·05	—	11·3	16·08	—
Gen. av., mm.	15·42			15·65			14·38			16·08		13·57			14·82			12·30		
Total in sample	58			6000			60			3		101			110			18		

Station ... Date ...	471 1. xi. 30			472 1. xi. 30			475 12. xi. 30		477 13. xi. 30			480 13. xi. 30			481 13. xi. 30			482 14. xi. 30		
Length mm.	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total
9·5–10·0	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
10·0–10·5	3	—	3	—	—	—	—	—	—	—	—	—	—	—	2	—	2	—	—	—
10·5–11·0	2	—	2	1	—	1	—	—	—	—	—	—	—	—	1	—	1	—	—	—
11·0–11·5	6	1	7	1	—	1	—	—	1	—	1	—	—	—	1	—	1	1	—	1
11·5–12·0	4	2	6	5	—	5	2	2	1	—	1	—	—	—	2	—	2	—	—	—
12·0–12·5	8	4	12	5	1	6	—	—	—	—	—	—	—	—	3	—	3	—	—	—
12·5–13·0	6	10	16	7	5	12	—	—	1	—	1	—	—	—	2	1	3	—	—	—
13·0–13·5	—	16	16	7	9	16	—	—	—	—	—	2	—	2	3	1	4	—	—	—
13·5–14·0	—	9	9	7	12	19	—	—	—	—	—	—	—	—	3	3	6	—	—	—
14·0–14·5	—	4	4	3	7	10	—	—	1	—	1	—	—	—	2	6	8	—	—	—
14·5–15·0	—	6	6	1	10	11	—	—	—	—	—	—	—	—	3	7	10	1	—	1
15·0–15·5	—	4	4	1	8	9	—	—	—	—	—	—	—	—	2	6	8	—	—	—
15·5–16·0	—	3	3	—	4	4	—	—	—	—	—	—	1	1	1	7	8	—	—	—
16·0–16·5	—	4	4	—	3	3	—	—	—	—	—	—	—	—	—	9	9	—	—	—
16·5–17·0	—	2	2	—	3	3	—	—	—	1	1	—	—	—	—	7	7	—	—	—
17·0–17·5	—	3	3	—	—	—	—	—	—	—	—	—	—	—	—	5	5	—	—	—
17·5–18·0	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	5	5	—	—	—
18·0–18·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6	6	—	—	—
18·5–19·0	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	4	4	—	—	—
19·0–19·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	2	—	1	1
19·5–20·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	2	—	—	—
20·0–20·5	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—
20·5–21·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	2	—	—	—
21·0–21·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—
21·5–22·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—
Total	30	70	100	38	62	100	—	2	4	2	6	2	1	3	25	75	100	2	1	3
Percentage	30	70	—	38	62	—	100	—	66·7	33·3	—	66·7	33·3	—	25	75	—	66·7	33·3	—
Av. length, mm.	11·70	14·11	—	12·97	14·38	—	11·75	—	12·50	18·50	—	13·25	15·75	—	13·15	16·58	—	13·0	19·25	—
Gen. av., mm.	13·39			13·85			11·75		14·50			14·08			15·72			15·08		
Total in sample	6410			520			2		6			3			103			3		

Station … Date …	483 14. xi. 30			484 16. xi. 30			485 16. xi. 30			486 16. xi. 30			487 16. xi. 30			488 17. xi. 30		
Length mm.	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total
9·5–10·0	—	—	—	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—
10·0–10·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1
10·5–11·0	—	—	—	—	—	—	—	—	—	1	—	1	—	—	—	1	—	1
11·0–11·5	1	—	1	1	1	2	—	—	—	—	—	—	—	—	—	—	—	—
11·5–12·0	2	—	2	2	1	3	—	—	—	—	—	—	2	—	2	2	—	2
12·0–12·5	2	1	3	1	—	1	—	—	—	—	—	—	3	—	3	4	—	4
12·5–13·0	1	3	4	1	3	4	1	1	2	2	—	2	6	2	8	3	—	3
13·0–13·5	2	2	4	2	4	6	—	—	—	1	—	1	3	—	3	5	—	5
13·5–14·0	4	7	11	—	3	3	—	—	—	1	2	3	3	8	11	3	1	4
14·0–14·5	4	3	7	—	4	4	—	1	1	—	—	—	—	5	5	1	2	3
14·5–15·0	2	6	8	1	2	3	—	—	—	—	—	—	2	6	8	5	6	11
15·0–15·5	1	9	10	—	3	3	—	—	—	—	—	—	1	5	6	2	3	5
15·5–16·0	—	5	5	—	6	6	—	2	2	—	2	2	2	5	7	—	7	7
16·0–16·5	—	7	7	—	6	6	—	2	2	—	—	—	1	9	10	—	4	4
16·5–17·0	—	11	11	—	4	4	—	1	1	—	2	2	—	7	7	—	6	6
17·0–17·5	—	9	9	—	6	6	—	2	2	—	—	—	—	9	9	—	6	6
17·5–18·0	—	5	5	—	11	11	—	5	5	—	—	—	—	3	3	—	3	3
18·0–18·5	—	1	1	—	10	10	—	1	1	—	—	—	—	1	1	—	—	—
18·5–19·0	—	5	5	—	7	7	—	—	—	—	—	—	—	4	4	—	3	3
19·0–19·5	—	2	2	—	5	5	—	1	1	—	—	—	—	2	2	—	3	3
19·5–20·0	—	1	1	—	5	5	—	—	—	—	—	—	—	4	4	—	1	1
20·0–20·5	—	2	2	—	—	—	—	2	2	—	—	—	—	4	4	—	1	1
20·5–21·0	—	1	1	—	2	2	—	—	—	—	—	—	—	—	—	—	2	2
21·0–21·5	—	—	—	—	2	2	—	1	1	—	1	1	—	1	1	—	—	—
21·5–22·0	—	1	1	—	1	1	—	—	—	—	—	—	—	1	1	—	—	—
22·0–22·5	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—
Total	19	81	100	9	86	95	1	19	20	5	7	12	23	77	100	27	48	75
Percentage	19	81	—	9·5	90·5	—	5	95	—	42	58	—	23	77	—	36	64	—
Av. length, mm.	13·43	16·12	—	12·31	16·98	—	12·75	17·38	—	12·65	16·11	—	13·49	16·61	—	13·25	16·76	—
Gen. av., mm.	15·71			16·53			17·15			14·66			15·90			15·5		
Total in sample	25,800			46,560			100			19			290			78		

Station … Date …	489 17. xi. 30			490 17. xi. 30			491 17. xi. 30			492 18. xi. 30			493 18–19. xi. 30		
Length mm.	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total
11·0–11·5	1	—	1	—	—	—	5	—	5	1	—	1	—	—	—
11·5–12·0	—	—	—	—	—	—	2	—	2	—	—	—	—	—	—
12·0–12·5	—	—	—	—	—	—	4	—	4	2	—	2	1	—	1
12·5–13·0	1	—	1	—	—	—	6	—	6	3	1	4	—	—	—
13·0–13·5	—	—	—	—	—	—	2	3	5	3	—	3	—	—	—
13·5–14·0	2	1	3	—	—	—	5	5	10	2	3	5	—	—	—
14·0–14·5	—	—	—	1	—	1	2	5	7	2	3	5	—	—	—
14·5–15·0	1	1	2	—	1	1	2	8	10	1	7	8	—	—	—
15·0–15·5	—	2	2	—	—	—	2	3	5	1	8	9	—	1	1
15·5–16·0	—	—	—	—	—	—	1	8	9	—	3	3	—	—	—
16·0–16·5	—	—	—	—	1	1	—	2	2	—	3	3	—	1	1
16·5–17·0	—	—	—	—	—	—	—	6	6	—	10	10	—	1	1
17·0–17·5	—	—	—	—	—	—	—	3	3	—	8	8	—	1	1
17·5–18·0	—	—	—	—	—	—	—	7	7	—	7	7	—	1	1
18·0–18·5	—	—	—	—	—	—	—	4	4	—	9	9	—	1	1
18·5–19·0	—	—	—	—	1	1	—	7	7	—	8	8	—	—	—
19·0–19·5	—	1	1	—	—	—	—	5	5	—	5	5	—	1	1
19·5–20·0	—	—	—	—	—	—	—	1	1	—	2	2	—	1	1
20·0–20·5	—	—	—	—	—	—	—	—	—	—	1	1	—	4	4
20·5–21·0	—	—	—	—	—	—	—	—	—	—	3	3	—	1	1
21·0–21·5	—	—	—	—	—	—	—	1	1	—	1	1	—	—	—
21·5–22·0	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
22·0–22·5	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—
22·5–23·0	—	—	—	—	—	—	—	1	1	—	—	—	—	1	1
23·0–23·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
23·5–24·0	—	—	—	—	—	—	—	—	—	—	2	2	—	—	—
Total	5	5	10	1	3	4	31	69	100	15	85	100	1	15	16
Percentage	50	50	—	25	75	—	31	69	—	15	85	—	6	94	—
Av. length, mm.	13·25	15·65	—	14·25	16·58	—	13·05	16·56	—	13·32	17·31	—	12·25	19·12	—
Gen. av., mm.	14·45			16·00			15·48			16·71			18·69		
Total in sample	16			4			226			31,200			49		

Station … Date …	494 19. xi. 30			495 19. xi. 30			496 19. xi. 30			498 21. xi. 30			499 21. xi. 30		500 21. xi. 30		
Length mm.	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Adolescent	Total	Furcilia 6	Adolescent	Total
12·0–12·5	1	—	1	—	—	—	—	—	—	1	—	1	—	—	—	—	—
12·5–13·0	2	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—
13·0–13·5	—	1	1	—	—	—	—	—	—	—	—	—	—	—	2	2	4
13·5–14·0	—	—	—	—	—	—	1	—	1	—	—	—	—	—	2	2	4
14·0–14·5	1	—	1	—	—	—	—	—	—	1	—	1	—	—	3	4	7
14·5–15·0	3	2	5	1	2	3	1	—	1	—	—	—	—	—	2	5	7
15·0–15·5	5	1	6	—	—	—	—	—	—	—	—	—	—	—	—	6	6
15·5–16·0	1	5	6	—	—	—	—	4	4	—	—	—	—	—	3	7	10
16·0–16·5	3	12	15	—	—	—	—	—	—	—	—	—	—	—	—	6	6
16·5–17·0	—	11	11	—	1	1	—	1	1	—	—	—	—	—	—	8	8
17·0–17·5	—	8	8	—	1	1	—	1	1	—	—	—	—	—	—	7	7
17·5–18·0	—	10	10	—	—	—	—	—	—	—	—	—	2	2	—	7	7
18·0–18·5	—	9	9	—	—	—	—	—	—	—	1	1	—	—	—	4	4
18·5–19·0	—	3	3	—	1	1	—	—	—	—	—	—	—	—	—	3	3
19·0–19·5	—	3	3	—	1	1	—	—	—	—	1	1	—	—	—	7	7
19·5–20·0	—	6	6	—	2	2	—	—	—	—	—	—	—	—	—	5	5
20·0–20·5	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	3	3
20·5–21·0	—	3	3	—	—	—	—	—	—	—	—	—	—	—	—	1	1
21·0–21·5	—	2	2	—	1	1	—	—	—	—	—	—	—	—	—	—	—
21·5–22·0	—	2	2	—	—	—	—	—	—	—	—	—	—	—	—	2	2
22·0–22·5	—	2	2	—	—	—	—	—	—	—	—	—	—	—	—	3	3
22·5–23·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
23·0–23·5	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	1	1
23·5–24·0	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	2	2
24·0–24·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
24·5–25·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
25·0–25·5	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
25·5–26·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
26·0–26·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
26·5–27·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
Total	16	84	100	1	9	10	2	6	8	2	2	4	2	2	12	88	100
Percentage	16	84	—	10	90	—	25	75	—	50	50	—	100	—	12	88	—
Av. length, mm.	14·81	18·01	—	14·75	18·03	—	14·25	16·17	—	13·25	18·75	—	17·75	—	14·46	17·45	—
Gen. av., mm.	17·50			17·70			15·69			16·00			17·75		17·09		
Total in sample	[illegible]			28			9			4			2		125		

Station ... Date ...	502 22. xi. 30			503 23. xi. 30		506 23. xi. 30		507 23. xi. 30			508 24. xi. 30		509 24. xi. 30			511 25. xi. 30	
Length mm.	Furcilia 6	Adolescent	Total	Adolescent	Total	Adolescent	Total	Furcilia 6	Adolescent	Total	Adolescent	Total	Furcilia 6	Adolescent	Total	Adolescent	Total
11·5–12·0	—	—	—	—	—	—	—	1	—	1	—	—	—	—	—	—	—
12·0–12·5	—	—	—	—	—	—	—	1	—	1	—	—	—	—	—	—	—
12·5–13·0	—	—	—	1	1	—	—	4	—	4	—	—	—	—	—	—	—
13·0–13·5	—	—	—	—	—	—	—	1	—	1	—	—	—	—	—	—	—
13·5–14·0	—	2	2	—	—	1	1	1	1	2	—	—	—	—	—	—	—
14·0–14·5	2	—	2	—	—	—	—	1	—	1	—	—	—	—	—	—	—
14·5–15·0	1	—	1	2	2	2	2	2	6	8	—	—	—	—	—	—	—
15·0–15·5	—	3	3	—	—	—	—	1	6	7	—	—	—	—	—	—	—
15·5–16·0	3	4	7	1	1	—	—	2	7	9	—	—	1	—	1	—	—
16·0–16·5	—	3	3	4	4	—	—	—	10	10	—	—	—	—	—	—	—
16·5–17·0	3	9	12	7	7	—	—	—	6	6	—	—	—	1	1	—	—
17·0–17·5	—	2	2	7	7	—	—	—	7	7	—	—	—	1	1	—	—
17·5–18·0	—	3	3	6	6	—	—	—	6	6	—	—	—	1	1	2	2
18·0–18·5	—	3	3	4	4	—	—	—	5	5	—	—	—	1	1	2	2
18·5–19·0	—	5	5	4	4	—	—	—	10	10	—	—	—	—	—	2	2
19·0–19·5	—	2	2	3	3	1	1	—	3	3	—	—	—	—	—	4	4
19·5–20·0	—	6	6	4	4	1	1	—	8	8	—	—	—	—	—	2	2
20·0–20·5	—	2	2	1	1	1	1	—	2	2	—	—	—	—	—	3	3
20·5–21·0	—	6	6	2	2	—	—	—	3	3	—	—	—	—	—	1	1
21·0–21·5	—	1	1	—	—	—	—	—	2	2	1	1	—	—	—	3	3
21·5–22·0	—	3	3	2	2	—	—	—	1	1	—	—	—	—	—	5	5
22·0–22·5	—	1	1	1	1	—	—	—	1	1	—	—	—	—	—	1	1
22·5–23·0	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	3	3
23·0–23·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
23·5–24·0	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—
24·0–24·5	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	2	2
24·5–25·0	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	1	1
25·0–25·5	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
25·5–26·0	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	1	1
Total	9	58	67	50	50	6	6	14	86	100	1	1	1	4	5	32	32
Percentage	13	87	—	100	—	100	—	14	86	—	100	—	20	80	—	100	—
Av. length, mm.	15·64	18·59	—	18·05	—	17·08	—	13·03	17·75	—	21·25	—	15·75	17·50	—	20·92	—
Gen. av., mm.	18·19			18·05		17·08		17·19			21·25		17·15			20·92	
Total in sample	67			119		6		2100			1		6			32	

Station ...	512		513		514			516		517		518			519	
Date ...	25. xi. 30		25. xi. 30		26. xi. 30			26. xi. 30		26. xi. 30		27. xi. 30			27. xi. 30	
Length mm.	Adolescent	Total	Adolescent	Total	Furcilia 6	Adolescent	Total	Adolescent	Total	Adolescent	Total	Furcilia 6	Adolescent	Total	Adolescent	Total
14·5–15·0	—	—	—	—	—	1	1	—	—	—	—	1	1	2	—	—
15·0–15·5	—	—	—	—	—	1	1	—	—	—	—	—	1	1	—	—
15·5–16·0	—	—	1	1	—	1	1	—	—	1	1	1	—	1	—	—
16·0–16·5	—	—	—	—	—	3	3	—	—	—	—	—	—	—	—	—
16·5–17·0	—	—	—	—	1	—	1	—	—	1	1	1	—	1	—	—
17·0–17·5	—	—	—	—	—	—	—	—	—	1	1	—	1	1	—	—
17·5–18·0	—	—	—	—	—	1	1	1	1	2	2	—	5	5	—	—
18·0–18·5	—	—	—	—	—	1	1	—	—	3	3	—	5	5	—	—
18·5–19·0	—	—	1	1	—	—	—	—	—	5	5	—	5	5	1	1
19·0–19·5	—	—	—	—	—	—	—	1	1	2	2	—	3	3	—	—
19·5–20·0	1	1	—	—	—	1	1	1	1	6	6	—	3	3	—	—
20·0–20·5	—	—	—	—	—	—	—	1	1	2	2	—	2	2	—	—
20·5–21·0	—	—	—	—	—	—	—	2	2	6	6	—	6	6	—	—
21·0–21·5	—	—	—	—	—	1	1	1	1	4	4	—	6	6	1	1
21·5–22·0	—	—	—	—	—	—	—	—	—	7	7	—	3	3	1	1
22·0–22·5	—	—	—	—	—	—	—	—	—	8	8	—	6	6	—	—
22·5–23·0	—	—	—	—	—	—	—	1	1	10	10	—	5	5	—	—
23·0–23·5	—	—	—	—	—	—	—	—	—	9	9	—	1	1	—	—
23·5–24·0	—	—	—	—	—	1	1	2	2	10	10	—	3	3	—	—
24·0–24·5	—	—	—	—	—	—	—	1	1	1	1	—	2	2	—	—
24·5–25·0	—	—	—	—	—	—	—	1	1	6	6	—	4	4	—	—
25·0–25·5	—	—	—	—	—	—	—	—	—	3	3	—	3	3	—	—
25·5–26·0	—	—	—	—	—	—	—	—	—	5	5	—	3	3	—	—
26·0–26·5	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—
26·5–27·0	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—
27·0–27·5	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—
27·5–28·0	—	—	—	—	—	—	—	—	—	4	4	—	1	1	—	—
28·0–28·5	—	—	—	—	—	—	—	1	1	1	1	—	—	—	—	—
28·5–29·0	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—
29·0–29·5	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—
Total	1	1	2	2	1	11	12	13	13	100	100	3	71	74	3	3
Percentage	100	—	100	—	8	92	—	100	—	100	—	4	96	—	100	—
Av. length, mm.	19·75	—	17·25	—	16·75	17·75	—	22·09	—	22·47	—	15·75	21·39	—	20·58	—
Gen. av., mm.	19·75		17·25		17·67			22·09		22·47		21·16			20·58	
Total in sample	1		2		12			13		956		87			4	

Station ...	520		521		522		523		525		537		543			547	
Date ...	28. xi. 30		28. xi. 30		28. xi. 30		29. xi. 30		29. xi. 30		19. xii. 30		20. xii. 30			20. xii. 30	
Length mm.	Adolescent	Total	Furcilia 6	Total	Adolescent	Total	Adolescent	Total	Adolescent	Total	Adolescent	Total	Furcilia 6	Adolescent	Total	Adolescent	Total
14·5–15·0	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1	—	—
15·0–15·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
15·5–16·0	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—
16·0–16·5	—	—	—	—	—	—	—	—	2	2	—	—	—	—	—	—	—
16·5–17·0	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—
17·0–17·5	—	—	—	—	1	1	1	1	1	1	1	1	—	—	—	1	1
17·5–18·0	—	—	—	—	—	—	2	2	—	—	2	2	—	—	—	—	—
18·0–18·5	—	—	—	—	—	—	3	3	—	—	—	—	—	—	—	—	—
18·5–19·0	3	3	—	—	1	1	4	4	—	—	3	3	—	—	—	—	—
19·0–19·5	2	2	—	—	—	—	4	4	1	1	1	1	—	1	1	—	—
19·5–20·0	—	—	—	—	—	—	9	9	—	—	6	6	—	—	—	—	—
20·0–20·5	—	—	—	—	—	—	5	5	1	1	8	8	—	—	—	—	—
20·5–21·0	2	2	—	—	—	—	15	15	—	—	10	10	—	—	—	—	—
21·0–21·5	1	1	—	—	—	—	4	4	—	—	7	7	—	—	—	—	—
21·5–22·0	—	—	—	—	—	—	8	8	—	—	12	12	—	—	—	—	—
22·0–22·5	2	2	—	—	—	—	4	4	1	1	16	16	—	—	—	—	—
22·5–23·0	1	1	—	—	—	—	10	10	1	1	10	10	—	—	—	—	—
23·0–23·5	—	—	—	—	—	—	4	4	—	—	6	6	—	—	—	1	1
23·5–24·0	2	2	—	—	—	—	9	9	—	—	5	5	—	—	—	—	—
24·0–24·5	1	1	—	—	—	—	4	4	—	—	4	4	—	—	—	—	—
24·5–25·0	—	—	—	—	—	—	6	6	—	—	6	6	—	—	—	—	—
25·0–25·5	—	—	—	—	—	—	2	2	—	—	—	—	—	—	—	—	—
25·5–26·0	1	1	—	—	—	—	4	4	—	—	2	2	—	—	—	—	—
26·0–26·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
26·5–27·0	—	—	—	—	—	—	1	1	—	—	1	1	—	—	—	—	—
27·0–27·5	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—
27·5–28·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
28·0–28·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
28·5–29·0	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—
Total	15	15	1	1	2	2	100	100	9	9	100	100	1	1	2	2	2
Percentage	100	—	100	—	100	—	100	—	100	—	100	—	50	50	—	100	—
Av. length, mm.	21·48	—	15·75	—	18·00	—	21·85	—	19·97	—	21·90	—	14·75	19·25	—	20·50	—
Gen. av., mm.	21·48		15·75		18·00		21·85		19·97		21·90		17·00			20·50	
Total in sample	15		1		2		11,400		9		7536		2			2	

APPENDIX II

Numbers and lengths of larvae taken during a twenty-four hour period at St. 461, 21. x. 30

Time ...	1434–1457												1830–1851									
Net ... Depth, m. ...	A I 80–0		A II 170–80		A III 270–170		A IV 385–270		A V 510–385		A VI 650–510		B I 75–0		B II 160–75		B III 255–160		B IV 345–255		B V 440–345	
Length mm.	Furcilia 6	Adolescent	Furcilia 6	Adolescent	Furcilia 6	Adolescent	Furcilia 6	Adolescent	Furcilia 6	Adolescent	Furcilia 6	Adolescent	Furcilia 6	Adolescent	Furcilia 6	Adolescent	Furcilia 6	Adolescent	Furcilia 6	Adolescent	Furcilia 6	Adolescent
9·5–10·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
10·0–10·5	—	—	1	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
10·5–11·0	—	—	1	—	3	—	1	—	—	—	1	—	—	—	3	—	—	—	—	—	—	—
11·0–11·5	1	—	3	1	1	—	3	—	1	—	—	—	—	—	3	—	—	—	—	—	1	—
11·5–12·0	—	—	6	—	3	—	6	—	2	—	3	—	2	—	3	3	—	1	—	—	1	—
12·0–12·5	1	—	7	2	2	—	2	1	1	2	3	1	1	—	4	1	—	—	—	—	1	—
12·5–13·0	1	4	3	5	1	4	3	5	—	3	2	3	4	3	4	6	—	—	—	—	2	3
13·0–13·5	3	5	—	3	2	3	—	1	—	3	—	6	1	5	—	3	—	2	—	—	—	2
13·5–14·0	—	5	1	4	—	7	2	6	—	7	2	7	1	6	—	7	—	1	—	1	1	5
14·0–14·5	1	11	—	6	—	6	—	3	—	6	1	3	—	5	—	2	—	3	—	2	—	5
14·5–15·0	—	6	—	3	—	3	—	4	—	8	—	3	—	6	—	3	—	4	—	1	—	1
15·0–15·5	—	3	—	2	—	2	—	4	—	3	—	8	—	5	—	2	—	2	—	—	—	1
15·5–16·0	—	3	—	—	—	6	—	2	—	8	—	—	—	6	—	3	—	3	—	—	—	3
16·0–16·5	—	3	—	1	—	3	—	4	—	3	—	1	—	1	—	1	—	—	—	1	—	1
16·5–17·0	—	2	—	1	—	1	—	—	—	—	—	3	—	2	—	—	—	2	—	—	—	—
17·0–17·5	—	—	—	—	—	—	—	—	—	1	—	1	—	—	—	—	—	—	—	—	—	—
17·5–18·0	—	—	—	—	—	1	—	1	—	—	—	—	—	1	—	—	—	—	—	—	—	—
18·0–18·5	—	—	—	—	—	—	—	1	—	1	—	—	—	1	—	1	—	—	—	—	—	—
18·5–19·0	—	—	—	—	—	1	—	1	—	—	—	—	—	—	—	1	—	—	—	—	—	—
19·0–19·5	—	1	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—
19·5–20·0	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—
20·0–20·5	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
20·5–21·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	7	43	22	28	12	38	17	33	5	45	12	38	9	41	17	33	—	18	—	5	6	21
Percentage	14	86	44	56	24	76	34	66	10	90	24	76	18	82	34	66	—	100	—	100	22	78
Av. length, mm.	12·89	14·55	11·95	13·83	11·89	14·84	12·07	14·72	11·45	14·63	12·50	14·68	12·64	14·71	11·84	14·05	—	14·72	—	14·65	12·42	14·20
Total in sample	1450		148		109		193		143		166		2800		172		18		5		27	

Time ...	1830–1851 (*cont.*)		2236–2259												0237–0300							
Net ... Depth, m....	B VI 520–440		C I 95–0		C II 200–95		C III 310–200		C IV 420–310		C V 535–420		C VI 660–535		D I 85–0		D II 180–85		D III 280–180		D IV 385–280	
Length mm.	Furcilia 6	Adolescent	Furcilia 6	Adolescent	Furcilia 6	Adolescent	Furcilia 6	Adolescent	Furcilia 6	Adolescent	Furcilia 6	Adolescent	Furcilia 6	Adolescent	Furcilia 6	Adolescent	Furcilia 6	Adolescent	Furcilia 6	Adolescent	Furcilia 6	Adolescent
9·5–10·0	—	—	1	—	—	—	1	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—
10·0–10·5	—	—	2	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—
10·5–11·0	1	—	—	—	—	—	—	—	—	—	1	—	1	—	2	—	—	—	—	—	—	—
11·0–11·5	—	—	—	—	—	—	—	—	1	—	1	—	2	—	5	—	—	—	—	—	—	—
11·5–12·0	—	—	2	—	—	—	1	1	4	3	3	—	2	1	4	2	1	—	1	—	—	—
12·0–12·5	—	1	11	2	—	1	2	—	4	2	2	—	—	1	6	2	—	—	1	1	—	1
12·5–13·0	1	3	2	2	1	—	2	7	1	6	3	6	—	4	4	6	1	—	3	4	1	2
13·0–13·5	—	4	1	6	1	—	1	7	2	10	3	4	1	2	—	3	—	—	—	5	—	—
13·5–14·0	1	8	—	6	—	1	—	8	—	4	—	4	1	3	1	2	—	4	—	7	—	2
14·0–14·5	—	5	—	5	—	—	—	3	—	—	2	4	1	11	—	3	—	2	—	6	—	2
14·5–15·0	—	8	—	3	—	2	—	6	—	5	1	5	—	6	—	—	—	6	—	9	—	1
15·0–15·5	—	3	—	1	—	—	—	4	—	—	—	4	—	3	—	2	—	6	—	4	—	1
15·5–16·0	—	7	—	3	—	—	—	3	—	4	—	—	—	4	—	3	—	7	—	2	—	4
16·0–16·5	—	1	—	—	—	—	—	—	—	1	—	3	—	2	—	1	—	10	—	2	—	1
16·5–17·0	—	3	—	2	—	—	—	1	—	—	—	1	—	1	—	1	—	7	—	1	—	2
17·0–17·5	—	3	—	1	—	—	—	1	—	—	—	2	—	1	—	—	—	3	—	1	—	—
17·5–18·0	—	1	—	—	—	—	—	1	—	1	—	1	—	1	—	—	—	3	—	3	—	—
18·0–18·5	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—
18·5–19·0	—	—	—	—	—	—	—	1	—	—	—	—	—	1	—	1	—	—	—	—	—	—
19·0–19·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
19·5–20·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
20·0–20·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
20·5–21·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	3	47	19	31	2	4	7	43	12	38	16	34	9	41	24	26	2	48	5	45	1	16
Percentage	6	94	38	62	33	67	14	86	24	76	32	68	18	82	48	52	4	96	10	90	6	94
Av. length, mm.	12·42	14·78	11·96	14·22	13·00	13·88	12·11	14·27	12·21	13·97	12·69	14·53	11·97	14·63	11·81	14·00	12·25	15·80	12·45	14·58	12·75	14·78
Total in sample	660		4180		7		483		864		565		435		1000		232		136		18	

Time ...	0237–0300 (*cont.*)				0629–0652										1025–1046		1429–1449		Total larvae
Net ... Depth, m. ...	D V 490–385		D VI 600–490		E I 75–0		E III 245–160		E IV 330–245		E V 420–330		E VI 515–420		F I 80–0		G I 95–0		
Length mm.	Furcilia 6	Adolescent	Furcilia 6	Adolescent	Furcilia 6	Adolescent	Furcilia 6	Adolescent	Furcilia 6	Adolescent	Furcilia 6	Adolescent	Furcilia 6	Adolescent	Furcilia 6	Adolescent	Furcilia 6	Adolescent	
9·5–10·0	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4
10·0–10·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6
10·5–11·0	—	—	—	—	2	—	—	—	1	—	—	—	—	—	—	—	—	—	17
11·0–11·5	—	—	—	—	1	—	—	—	1	—	—	—	—	—	—	—	3	—	28
11·5–12·0	1	—	—	—	1	—	—	—	—	—	—	—	—	—	1	—	4	—	62
12·0–12·5	2	1	1	—	—	—	—	—	—	—	—	—	—	—	1	1	2	2	76
12·5–13·0	—	1	—	1	—	1	—	—	—	—	—	1	—	1	2	1	1	5	129
13·0–13·5	—	6	—	—	—	—	—	—	—	—	—	—	—	—	1	2	—	4	102
13·5–14·0	2	3	—	1	—	—	—	—	—	1	—	—	—	—	—	1	—	5	128
14·0–14·5	—	6	—	1	—	3	—	1	—	—	—	—	—	—	—	—	1	7	117
14·5–15.0	—	3	—	—	—	2	—	—	—	2	—	—	—	—	—	1	—	5	107
15·0–15·5	—	4	—	1	—	1	—	1	—	—	—	—	—	—	—	—	—	3	70
15·5–16·0	—	2	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	1	76
16·0–16·5	—	2	—	—	—	3	—	1	—	1	—	—	—	—	—	—	—	1	48
16·5–17·0	—	2	—	3	—	4	—	—	—	—	—	—	—	—	—	—	—	2	41
17·0–17·5	—	1	—	1	—	—	—	—	—	—	—	—	—	—	—	1	—	—	18
17·5–18·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	14
18·0–18·5	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1	8
18·5–19·0	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	2	9
19·0–19·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	3
19·5–20·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
20·0–20·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
20·5–21·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	6	31	1	9	4	15	—	4	2	4	—	1	—	1	5	7	11	39	Grand total examined = 1165
Percentage	16	84	10	90	21	79	—	100	33	67	—	100	—	100	42	58	22	78	
Av. length, mm.	12·25	14·56	12·25	15·80	11·13	15·62	—	15·38	11·00	14·88	—	12·75	—	12·75	12·55	13·89	12·02	14·62	
Total in sample	41		10		25		4		7		2		4		13		3584		Grand total in all nets = 17,501

[*Discovery Reports. Vol. XIV, pp.* 193–324, *December*, 1936]

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INVESTIGATIONS

THE SOUTHERN SPECIES OF THE GENUS *EUPHAUSIA*

By

D. DILWYN JOHN, M.Sc
Assistant Keeper, Department of Zoology, British Museum of Natural History

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THE SOUTHERN SPECIES OF THE GENUS *EUPHAUSIA*

By D. DILWYN JOHN, M.Sc.

(Text-figures 1–40)

INTRODUCTION

This report is an account of the adult characters and distribution of ten species of *Euphausia* from southern waters, and of the development from the second Calyptopis stage upwards of five of those species.

The surface waters of the southern oceans are divided from south to north into three well-defined zones of waters of different origins: the Antarctic, sub-Antarctic and subtropical Zones. They are separated from one another by sharp boundaries, because, along the line where two meet, the heavier water of one zone does not mix with the lighter water of the other but sinks below the surface. Most of the species of *Euphausia* described here are found only in one or another of these zones.

The characters of the species, more particularly those of the copulatory organs of the males, show that five of the ten make one group and four another group. I think they show too that, if it be supposed that the genus *Euphausia* arose in tropical waters, the individuals of each group represent, in the order that they occur from north to south, successive steps towards the colonization of Antarctic waters by the genus along two distinct lines.

The ten species of *Euphausia* whose adult characters are described are:

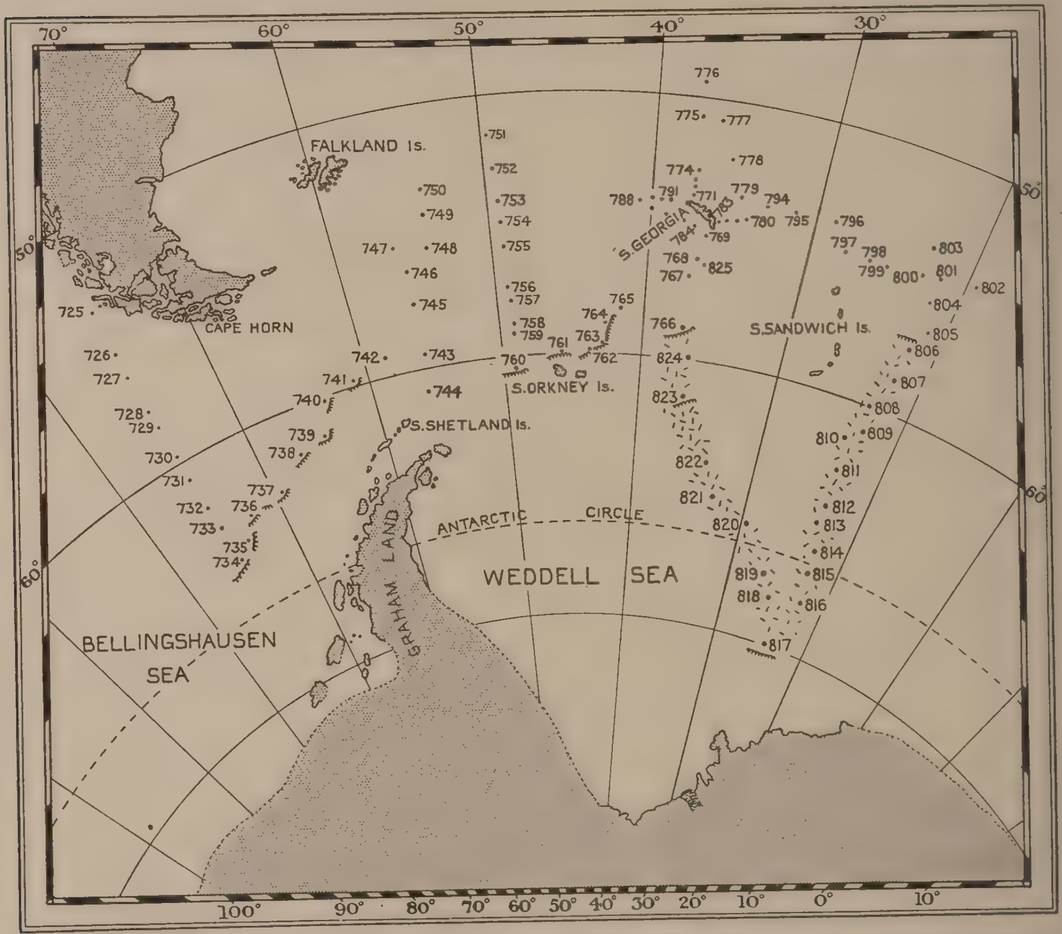
E. crystallorophias, Holt and Tattersall
E. superba, Dana
E. frigida, Hansen
E. vallentini, Stebbing
E. lucens, Hansen
E. triacantha, Holt and Tattersall
E. longirostris, Hansen
E. spinifera, Sars
E. hanseni, Zimmer
E. similis, Sars

The first seven species occur only in the Antarctic or sub-Antarctic Zones, except that *E. lucens* is found too in the coldest water of the subtropical Zone. *E. similis* is always present in all but the coldest water of the sub-Antarctic Zone and may occur throughout it; but it has a wider distribution than any of the other nine species: not only is it found like *E. lucens* in the coldest water of the subtropical Zone as well as in the sub-Antarctic, but it has been recorded from the neighbourhood of the Philippines and from off the south coast of Japan. To describe these eight species would be to describe a geographical unit, for they are the only members of the genus occurring in the Antarctic and sub-Antarctic Zones. *E. spinifera* from the subtropical Zone and *E. hanseni* from tropical waters are included because they are closely allied to *E. longirostris* and *E. triacantha*, and together with them form one of the groups mentioned above.

All the species have been described before, but the descriptions are in scattered publications; of some species a later worker has added to or corrected the description of an earlier without completely redescribing it; three varieties of *E. similis* have been described in three separate papers; some of the characters of *E. longirostris* have been described in one paper some in another; *E. hanseni* has been described from female specimens only, from an unknown locality; no previous worker has had a collection, such as the present one, large enough in numbers and wide enough in range to enable the limits of the distribution of most of the species to be recognized. For these reasons illustrated descriptions of the ten species are given here; the figures are new, the descriptions based upon new material.

The five species whose development from the second Calyptopis stage upwards is described are:

E. frigida	*E. longirostris*
E. vallentini	*E. spinifera*
E. triacantha	


70°
60°
50°
40°
30°
50°
60°
50°
60°
FALKLAND Is.
CAPE HORN
S.SHETLAND Is.
S.ORKNEY Is.
S.GEORGIA
S.SANDWICH Is.
ANTARCTIC CIRCLE
WEDDELL SEA
BELLINGSHAUSEN SEA
GRAHAM LAND
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40°
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20°
10°
0°
10°

Fig. 1. Chart showing positions of the stations made in the Falkland Sector in the summer of 1931–2. The position of the edge of the pack-ice is shown by a scalloped line, the loose pack-ice along the course of the cruise in the Weddell Sea by irregular hatching.

In each of these species there are a few Furcilia that occur in much larger numbers than the others; they are what were previously known as dominant forms. In each they have the structural relationship to one another that Fraser (1936, p. 35) has shown to be the essential one of dominant forms, proving them to be the members of a series. They confirm Fraser's view that this part of Euphausian development has an order that hitherto was unsuspected, and that it is therefore shorter than was previously supposed.

MATERIAL

The collection upon which this report is based is a small part of that made by the R.R.S. 'Discovery II' during her second commission, 1931–3. The stations made during that time are shown in Figs. 1–3. They include two sets of closely placed stations in the Falkland sector of the Antarctic, one made in each of the summer seasons 1931–2 and 1932–3 (Figs. 1 and 2). A series of lines of stations crossing and re-crossing

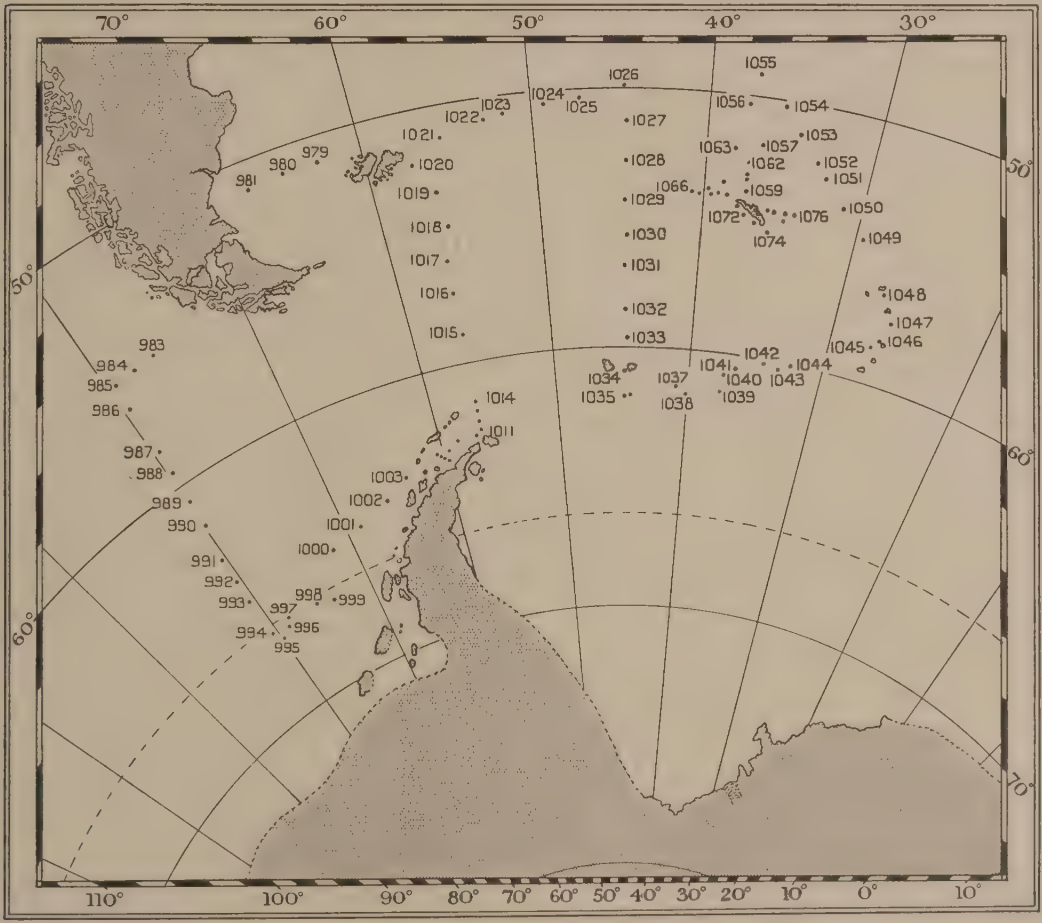
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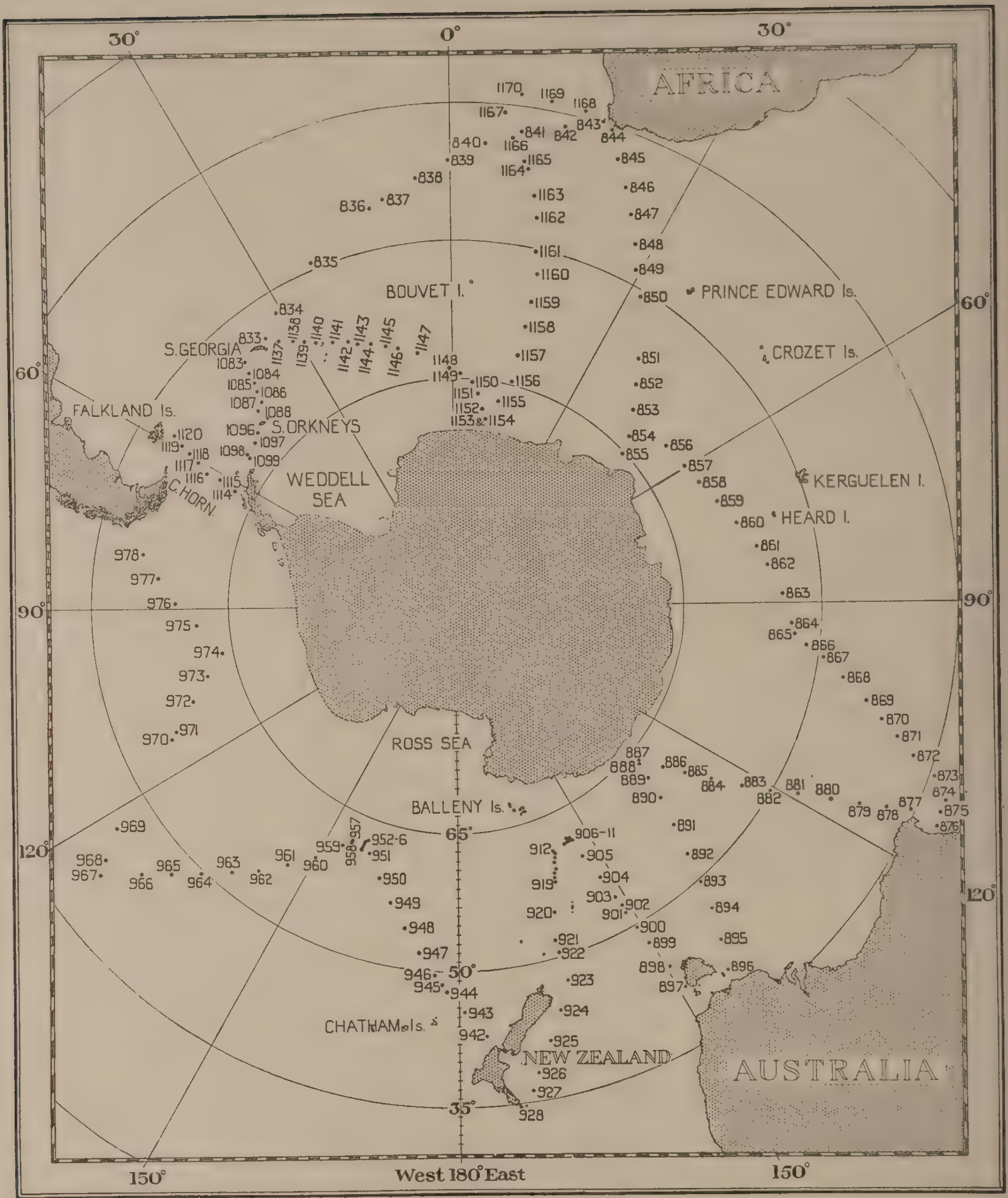
Fig. 2. Chart showing positions of the stations made in the Falkland Sector in the summer of 1932–3. The southernmost stations were along the edge of the pack-ice.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PRINCE EDWARD Is.
BOUVET I.
S.GEORGIA
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S.ORKNEYS
FALKLAND Is.
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C.HORN
WEDDELL SEA
60°
CROZET Is.
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KERGUELEN I.
HEARD I.
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NEW ZEALAND
AUSTRALIA
CHATHAM Is.
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978
90°
90°
120°
120°
ROSS SEA
BALLENY Is.
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50°
35°
150°
West 180° East
150°

Fig. 3. Chart showing positions of the stations made on the circumpolar cruises and of some in the Falkland Sector. Those from South Georgia to South Africa (833–843) were made in February and March 1932. Those east-about from South Africa to South America were made between April and October 1932; the turning point of each, except the last (974), was at the edge of the ice. Those between South Georgia and the Falkland Islands (1083–1120) were made between December 1932 and February 1933; those between South Georgia (1137) and the ice-edge (1153–4) and to South Africa (1170) in March 1933.

the Antarctic and sub-Antarctic and the coldest parts of the subtropical Zones, encircling the Antarctic continent east-about from South Africa to South America, was made in the winter months (April–October) of 1932. A line of stations from South Georgia to the ice-edge off the Antarctic continent near the meridian of Greenwich and from there to the Cape was made in March 1933 (Fig. 3).

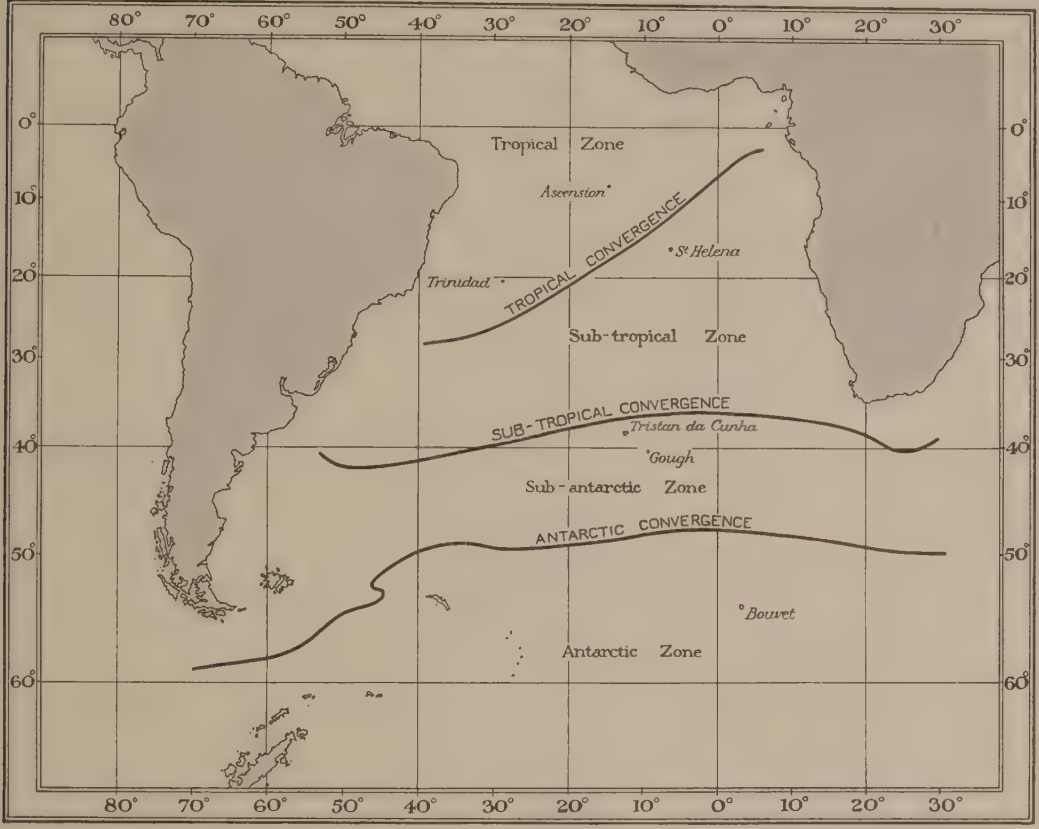
80° 70° 60° 50° 40° 30° 20° 10° 0° 10° 20° 30°
0° 10° 20° 30° 40° 50° 60°
Tropical Zone
Ascension
TROPICAL CONVERGENCE
St Helena
Trinidad
Sub-tropical Zone
SUB-TROPICAL CONVERGENCE
Tristan da Cunha
Gough
Sub-antarctic Zone
ANTARCTIC CONVERGENCE
Bouvet
Antarctic Zone

Fig. 4. Chart showing the probable average positions of the Antarctic, subtropical and tropical convergences in the South Atlantic (from Hart, 1934, *Discovery Reports*, VIII, p. 5).

The southern limit of the two sets of stations in the Falkland sector was the edge of the pack-ice—which had different positions in the two seasons—with the exception that the stations in the Weddell Sea during the first season were made in loose pack-ice itself. Each of the southern turning points of the circumpolar cruises was at the edge of the ice fringing the continent except that to the south-west of South America, where the amount of fuel remaining on the cruise from New Zealand was not enough for the ship to go on to the ice-edge.

Among the eleven hauls of plankton nets made at most of these stations were two oblique hauls, one from approximately 250 to 100 m., the other from approximately 100 m. to the surface, taken with a conical net with a mouth 1 m. in diameter and the greater portion of its fishing part of stramin. This is the N 100 fully described by Kemp and Hardy (1929, p. 184). The specimens of *Euphausia* in almost all those net hauls taken east-about from South Africa to South America and those from about half the net hauls made in the Falkland sector in each of the two seasons have been examined. Some of the larvae described were sought for and found in the hauls of a finer and smaller net, 70 cm. in diameter, fished vertically at the same stations, or in other collections; adult *E. crystallorophias* and *E. hanseni* are described from material collected at another time.[1]

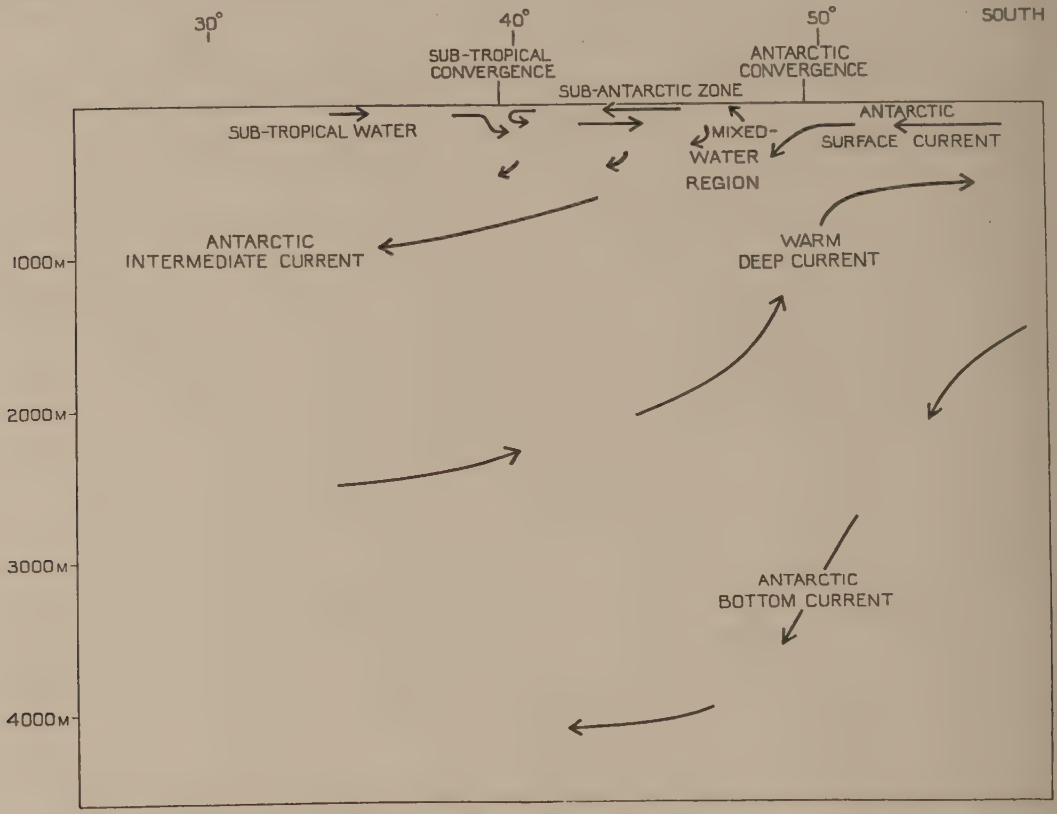
30°
40°
50°
SOUTH
SUB-TROPICAL CONVERGENCE
ANTARCTIC CONVERGENCE
SUB-ANTARCTIC ZONE
SUB-TROPICAL WATER
MIXED-WATER REGION
ANTARCTIC SURFACE CURRENT
ANTARCTIC INTERMEDIATE CURRENT
WARM DEEP CURRENT
ANTARCTIC BOTTOM CURRENT
1000M
2000M
3000M
4000M

Fig. 5. Vertical diagrammatic section showing the vertical and meridional ranges and movements of the water masses of the subtropical, sub-Antarctic and Antarctic Zones.

THE SURFACE WATERS OF THE SOUTHERN OCEANS[2]

The surface of the southern oceans is divided from south to north into three well-defined zones of different origins: the Antarctic, sub-Antarctic and subtropical Zones (Fig. 4). Where the waters of two zones meet the heavier sinks below the surface and sets up a hydrological boundary or *convergence*. The vertical and meridional movements of the waters of these zones and of the deep currents below them are shown diagrammatically in Fig. 5.

---

[1] The positions of all the stations are shown in Figs. 1–3. In charts showing the distribution of individual species the only stations included are those from which the Euphausians where examined.

[2] This section was written with the help of Mr G. E. R. Deacon, hydrologist, who will shortly be publishing in the *Discovery Reports* an account of the hydrology of the Southern Oceans.

The surface water of the southernmost, the Antarctic, zone is formed near the Antarctic continent and is a mixture of fresh water from melting ice and snow with upwelling deep water from the north (a part of the warm deep current to be described later). It is cold and poorly saline. It moves with the prevailing winds—towards the west near the continent, towards the east farther north—but it has as well a northerly flow which is probably small compared with the east or west movement. At a latitude which is determined by the deep-water movements (see Deacon, 1937, pp. 21–24) the Antarctic water sinks below the surface to form a deep current. Here, in this same latitude, it meets at the surface the lighter water of the next zone, the sub-Antarctic, and it is below this that it sinks sharply. The line along which this happens is known as the Antarctic convergence.[1] The depth of the Antarctic surface layer varies from about 80 m. in the far south between the east and west currents to 250 m. near the Antarctic convergence. Where the sub-Antarctic surface water meets the warmer water of the subtropical Zone it sinks below the surface along a line known as the subtropical convergence. There are reasons for believing that there is a less definite boundary separating subtropical and tropical water farther north. The Antarctic convergence runs uninterrupted by land around the southern hemisphere between the latitudes of 50 and 60° S. The course of the subtropical convergence between 37 and 47° S is broken by South America and New Zealand.

Sub-Antarctic surface water is formed from the northward flowing Antarctic water which has sunk below the surface at the Antarctic convergence and from subtropical water which enters the sub-Antarctic Zone from the north as a subsurface current. Its depth increases from south to north and it is about five times as thick as the Antarctic surface layer. Its strongest movement is towards the east, but it generally has a slow movement to the north as well. The subsurface stratum, which flows towards the south, is a mixture of more saline water from the subtropical Zone and of sub-Antarctic surface water itself that has sunk below the surface at the subtropical convergence. In the most southerly part of the sub-Antarctic Zone, for about 100 miles north of the Antarctic convergence, there is a region of intense vertical mixing where this warmer, more saline, water from the north is mixed with water from the surface of the Antarctic Zone. From this region the current known as the Antarctic intermediate current sinks and flows towards the north.

Below the northward flowing Antarctic intermediate current in the sub-Antarctic Zone is the southward flowing warm deep current. It climbs rapidly towards the surface at the Antarctic convergence and flows south beneath the surface layer in the Antarctic Zone. In the Atlantic and Indian Ocean sectors it comes from water which has sunk below the surface in tropical and subtropical regions; it is present in the Pacific Ocean but its origin is uncertain. Part of it upwells far south and mixes with the fresh water from melting ice and snow to form the Antarctic surface water; part of it becomes cooled but only slightly diluted and gives rise to the heavy Antarctic bottom water. Both waters have a northward movement. There is then in the Antarctic Zone a movement of cold water away from the pole at the surface and bottom and a movement of warmer water towards the pole at an intermediate depth.

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[1] The flow of Antarctic water to the north is strongest in summer when ice and snow are melting in the south. When new ice is being formed in winter it is considerably reduced. Our observations near the Antarctic convergence in winter suggest that the slowing up of the current leads to a southern movement of sub-Antarctic water at the surface; north of the convergence was purely sub-Antarctic water, but the Antarctic water south of it was mixed with sub-Antarctic water. At such times sub-Antarctic animals (e.g. *E. vallentini*, see p. 214) may be found south of the convergence.

Subtropical surface water is water which has spent some time circulating in subtropical or tropical regions. Near the subtropical convergence it appears to have either a component of movement towards the south or a smaller northward movement than the sub-Antarctic surface water.

There are generally sudden increases of temperature, and sometimes of salinity, as one crosses the convergences between the zones from south to north. The increase in temperature across the Antarctic convergence is 2 or 3° C.: where the convergence is far north (50° S) it is from about 1 to 3·5° C. in winter and from about 3·5 to 6° C. in summer; where the convergence is far south (60° S) the figures are 0 to 2·5° C. in winter, 2·5 to 5° C. in summer. In the Pacific Ocean and in the western part of the Atlantic Ocean there is a small increase of salinity across the convergence from south to north: from 33·8 or 33·9 °/₀₀ to 34·1 or 34·2 °/₀₀; the few observations in the eastern part of the Atlantic Ocean and the Indian Ocean make it appear that there is no increase there. The position of the convergence appears to be fixed by the deep-water movements, and so far as is known it varies only within very small limits.

The subtropical convergence is well defined in the Atlantic Ocean and the western part of the Indian Ocean. It is usually marked by a sudden increase of temperature of about 4° C., and of salinity of about 0·5 °/₀₀. It is not so well defined to the south of Australia and in the Tasman Sea. There have been very few observations in the Pacific Ocean, but the convergence appears to be well marked there except in the east. There have not been enough observations to give a full account of the temperature and salinity changes across the subtropical convergence, but it can be said that its position is approximately that of the 11·5° C. isotherm in winter, of the 14·5° C. isotherm in summer, and of the 34·9 °/₀₀ isohaline. It does not appear to be stationary everywhere like that of the Antarctic convergence. It seems to vary most in the Atlantic Ocean and, so far, a definite seasonal variation has been found only to the south of the Brazil current: there its average position is 3–5° farther south in summer than in winter. It has other variations which are not seasonal changes.

Briefly the surface temperature limits of the Antarctic, sub-Antarctic and subtropical Zones are as follows:

	In winter (August and September)	In summer (February and March)
Antarctic water:		
Where the convergence is in about 50° S	Less than 2° C.	Less than 4·5° C.
Where the convergence is in about 60° S	Less than 1° C.	Less than 3·5° C.
Sub-Antarctic water	2–11·5° C.	4·5–14·5° C.
Subtropical water	Greater than 11·5° C.	Greater than 14·5° C.

THE SPECIES AS ADULTS

The adults of the ten species described in this report are easily distinguished from one another by their structural characters. Both sexes of each may be recognized by the structure of the antennular peduncle, the shape of the rostrum and front part of the carapace, and the presence or absence of abdominal spines or processes; the males may be distinguished by the structure of the copulatory organ on the first pleopod. They can also be separated when fresh by one who has seen and examined many of them by their general appearance—that sum of all the small characteristics of shape and colouring

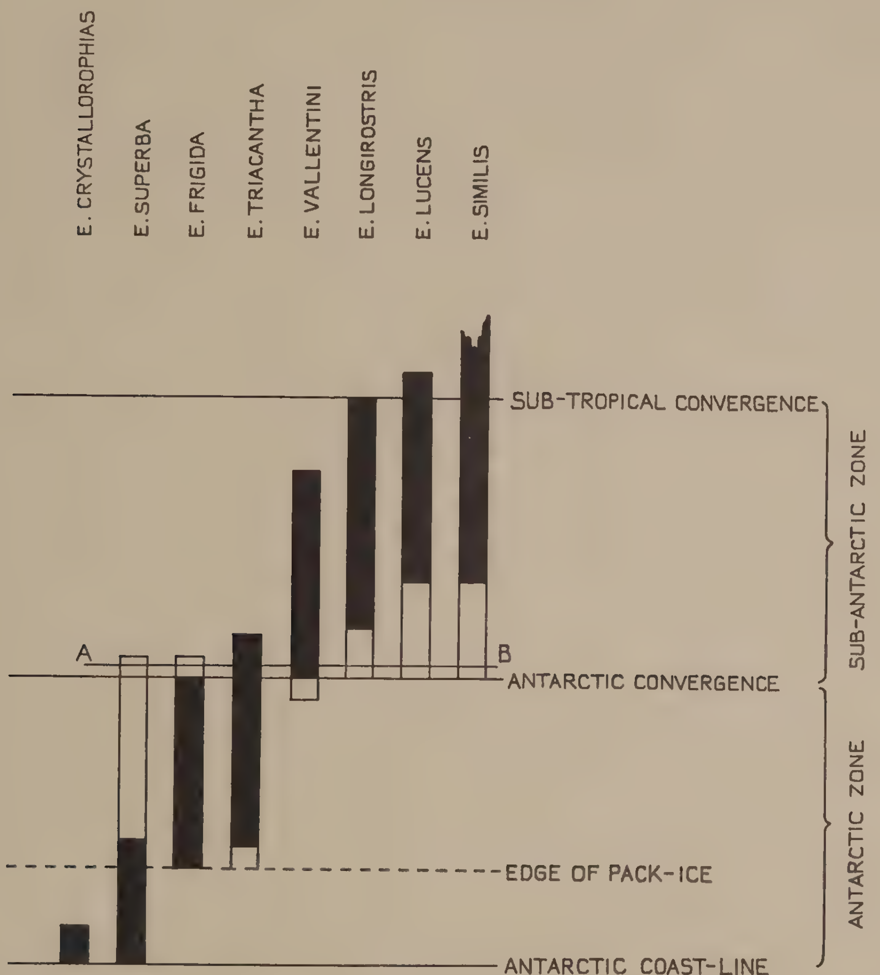

Fig. 6. Diagram showing the distribution of species of *Euphausia* in the surface waters of the Antarctic and sub-Antarctic Zones; the blacked in portion of each column shows the normal range of that species, the entire column the possible range.

which it is almost impossible to describe.[1] Some of the large species possess characteristic structures and rich colourings that make them easy to recognize with the naked eye: *E. superba* may be recognized by its densely plumose thoracic legs and strong red colouring, *E. triacantha* by its brilliant red and orange and its three abdominal spines. But the smaller species without such obvious structures or such conspicuous markings may be as readily distinguished from one another by their general appearance when many have been seen and handled.

The majority of the specimens that form the basis of a part of this report were identified at sea the day after they were taken. They were examined under a dissecting microscope and a large number of them were sexed and measured. The data so obtained will, it is hoped, be used for the preparation of another paper on the life histories of the species.

Eight of the ten species described here are the only *Euphausia* found in the Antarctic and sub-Antarctic Zones. Each of them, with the exception of *E. triacantha*, is normally confined not only to one of the two zones but to a part of one zone. But most of them may occur throughout the zone of which they normally occupy only a part, and some may be found even outside the zone to which they are usually confined. The more abnormal occurrences can mostly be explained by water movements that are local and peculiar for reasons of place or time, as the many examples described later in this report show.

The normal and the possible range of latitudinal distribution of each of the species is shown diagrammatically in Fig. 6.

The figure shows that the usual number of *Euphausia* to be found at one point in the sub-Antarctic is two, three or four. In the warmer sub-Antarctic *E. similis*, *E. lucens* and *E. longirostris* occur. A little farther south *E. vallentini* is added to the number. Farther still *E. lucens* and *E. similis* cease to occur and *E. triacantha* appears. *E. longirostris* is sometimes absent from the coldest water leaving only *E. vallentini* and *E. triacantha*.

In the ice-free part of the Antarctic Zone there are usually only *E. triacantha* and *E. frigida*, though in some large areas *E. superba* occurs too, widely distributed as far north as the convergence. Along and among the ice itself only *E. superba* is found. Farthest south of all is *E. crystallorophias*, a neritic species confined to the coast-line of the Antarctic continent.

The warmer sub-Antarctic species may be brought as far south as the Antarctic convergence, and *E. frigida* and *E. superba* may be carried a short way north of the convergence from the Antarctic. In this way it is possible that seven of the eight species may occur in one place, immediately north of the Antarctic convergence, and taken in one net. This is indicated by the section *AB* in the figure. The largest number taken at any of the 200 stations shown on the distribution charts in this report was five; that number occurred at six stations all immediately north of the Antarctic convergence.

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[1] I have not seen *E. hanseni* nor many specimens of *E. crystallorophias* in a fresh condition.

They were as follows:

At five stations:	At one station:
E. vallentini	*E. vallentini*
E. triacantha	*E. triacantha*
E. longirostris	*E. similis*
E. similis	*E. lucens*
E. frigida	*E. frigida*

The complicated copulatory organs of the males of the different species show constant and unmistakable differences and form the most reliable criterion for separating them. In the accounts of the organs that follow under each species more details are given than are necessary for their recognition, and than would be seen under the low power of a binocular microscope—indeed the figures alone are sufficient for recognition. The details have been given because they are necessary for the comparative account of the copulatory organs which follows (pp. 244–252); in it the ten species are divided into two groups, and it is suggested that the male copulatory organs show that the members of each group are related to one another as the members of an evolutionary series.

Hansen (1910, p. 79) says of the copulatory organs that "in all species (of *Euphausia*) hitherto examined by me a spine-shaped process on the inner lobe and additional processes on the median lobe are totally wanting". But in a later paper (1912, p. 230) he records seeing the spine-shaped process in one specimen of *E. lucens* and says that the additional process is present as a small spine in *E. mucronata* and as a mere rudiment in *E. gibboides*. Zimmer (1913, p. 117, pl. xiii, fig. 72, *p.a.*) says that he found in the specimens of *E. superba* he examined indications of the additional process on the median lobe in the form of a tiny spine.

I have seen a very small spine-shaped process on the inner lobe in two or three specimens of *E. superba*, but not in *E. lucens* nor in any of the other species. I find a small additional process on the median lobe to be present in every one of the ten species except *E. lucens*; in one specimen of *E. superba* there were two additional processes on the median lobe.

Euphausia lucens, Hansen (Figs. 7–11 and 30 *a*)

E. lucens, Hansen, 1905, p. 9; 1911, p. 26, fig. 8; Tattersall, 1913, p. 876; Hansen, 1915, p. 84; Zimmer, 1915, pp. 178–9; Colosi, 1917, p. 183, pl. xiv, figs. 6–8; Tattersall, 1924, p. 19; Illig, 1930, p. 499; Tattersall, 1925, p. 6; Hardy and Gunther, 1935, p. 208.
E. splendens (part), Sars, 1885, p. 80, pl. xiii, figs. 7–17.
E. uncinata, Colosi, 1917, p. 186, pl. xiv, figs. 9–10.

Description. The front margins of the carapace are very faintly convex behind each eye; the rostrum is a small broad triangle (Fig. 7).

In the antennule the lobe from the end of the first segment of the peduncle is triangular and variable in size; it may be very short, a small wide triangle, or it may be a long thin triangle one-third as long as the second segment of the peduncle. It is easily seen from the side. The dorsal keel of the third segment is strong; as seen from the side it appears to rise a little less than half-way along the segment; its upper margin is nearly straight or slightly curved.

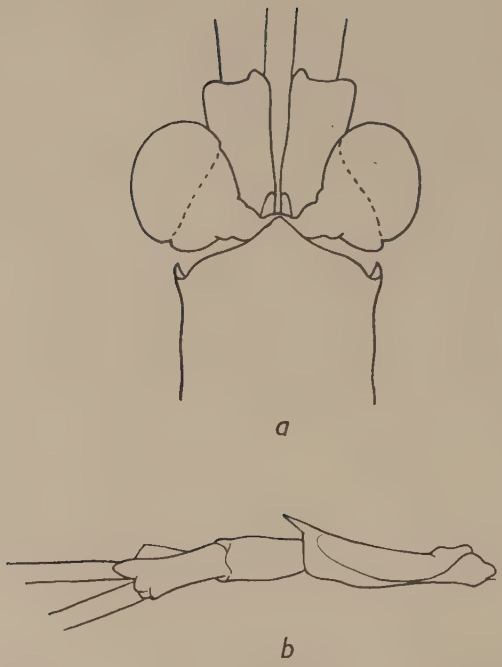


Fig. 7. *E. lucens*. *a*, front part of carapace and first segment of antennules from above, × 18. *b*, left antennular peduncle from the side, × 18.

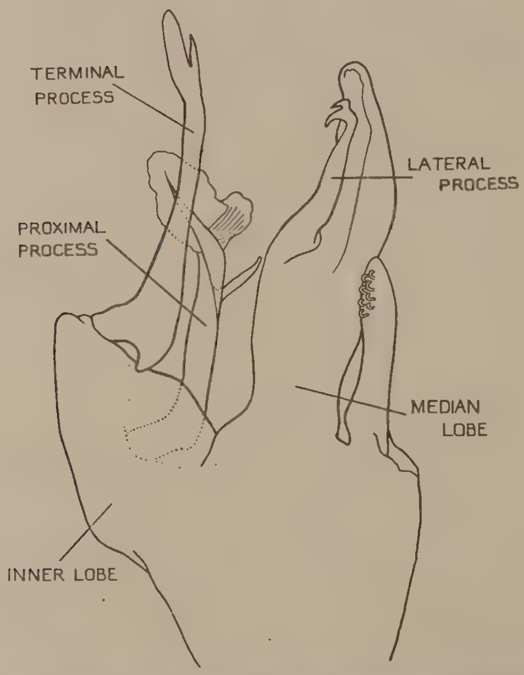

TERMINAL PROCESS
LATERAL PROCESS
PROXIMAL PROCESS
MEDIAN LOBE
INNER LOBE

Fig. 8. *E. lucens*, inner and median lobe of the left copulatory organ of the male, from behind, × 82.

The abdominal segments have no dorsal spines.

The copulatory organ of the male is very similar to that of *E. vallentini* and *E. frigida* but easy to distinguish from either of them (Figs. 8 and 30 *a*). It differs from both in that the terminal process is considerably longer than the proximal: in *E. vallentini* and *E. frigida* it is shorter. The end of the terminal process is bifid, the inner of the two branches longer and stronger than the outer. The end of the proximal process carries on its hindermost and on its forward side a membranous expansion; the latter is smaller than the former and is set a little farther back on the process (i.e. nearer its base) and does not extend so far forward; it has a striated appearance which the hindermost expansion has not. On the inner side of the distal end of the process, between the membranous expansions, there is a small tooth. Before the membranous expansions there springs from the outer side of the process a strong secondary process or spine which appears blade-like from some angles because one edge is more heavily chitinized than the other. The lateral process is strongly and sharply curved at the end and carries on that curve a strong tooth of a characteristic shape.

Males may be sexually mature at the length of 11 mm., females at 12 mm.—that is, specimens of these lengths have been seen carrying ripe spermatophores. Both sexes may, exceptionally, reach the length of 18 mm. The vast majority of the specimens found were between 10 and 15 mm. long.

E. lucens is the smallest of the species described in this paper. None of its larval stages has been described.

Remarks. I cannot agree with Hansen (1911, pp. 14–15) that the two specimens described by Illig (1908 *a*, pp. 54–5, figs. 1, 2) as *Thysanopoda megalops*, sp.nov., cancelled by him later in the same year (Illig, 1908 *b*, p. 463), were possibly *E. lucens*. Both were 20 mm. long, longer than any *E. lucens* I have seen; they had, according to Illig, no denticles on the under edge of the carapace and no lappet on the basal segment of the antennular peduncle; they had a median spine above the base of the eye-stalks; and they differed in other ways from *E. lucens*.

Colosi (1917, pp. 186–7, pl. xiv, figs. 9 and 10) described the new species *E. uncinata* from one male found among seventy specimens of *E. lucens*. It differed from *E. lucens* in only one way: the median lobe of the copulatory organ of the male had at the base of the lateral process an additional and smaller process, uncinate in shape with a strong secondary tooth near its apex. Tattersall (1924, p. 20) thought it reasonable to regard this as an abnormal male of *E. lucens*. I am satisfied that it is of this species and that what Colosi saw and drew as an additional process was not that but the lateral process of the succeeding moult, displaced perhaps in fixation. I have seen the same thing in *E. lucens* itself (Fig. 9 *a*) and in *E. spinifera* (Fig. 28 *b* 1), and there was no doubt that the additional process was within the tissues of the median lobe; its apex lay below or within the base of the lateral process. The appearance does not, however, seem to be a common one in the species of *Euphausia* described in this report. I have noticed it often in *Thysanoëssa vicina*, in which it is not uncommon to see the rudiments of the three larger processes, the terminal, the proximal and the lateral, protruding for a longer or a shorter way up into these processes; one such is shown in Fig. 9 *b*.

In his report on a collection of Schizopoda from the tropical Pacific, which contained no *E. lucens*, Hansen (1912, p. 230) in discussing the male copulatory organ of the genus *Euphausia* says: "The spine-shaped process is wanting (yet I found this process developed in the normal way in one of the specimens examined of *E. lucens*)." I have found no reference to this in any other work by Hansen, nor have I ever seen the spine-shaped process in *E. lucens*.

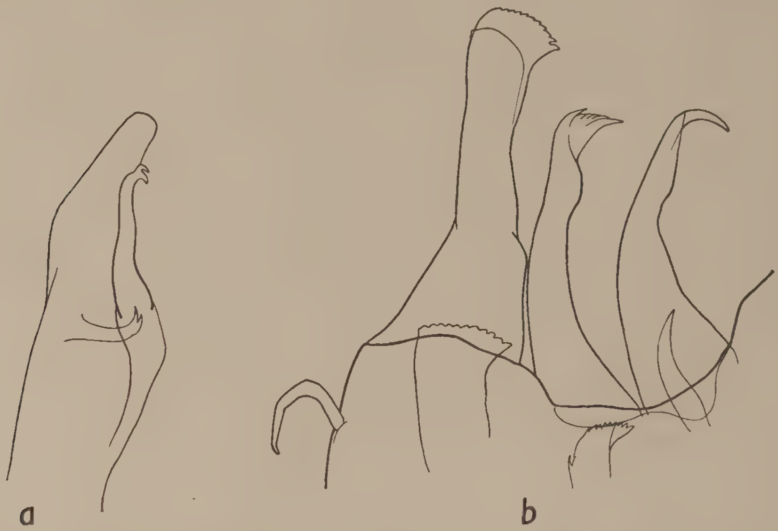


Fig. 9. *a*, *E. lucens*, median lobe of the left copulatory organ of a male from in front, ×67. *b*, *Thysanoessa vicina*, terminal proximal and lateral processes of the left copulatory organ of a male from behind, ×266. Both figures show the rudiments of the processes of the succeeding moult at the bases of the existing processes.

Distribution. The stations at which *E. lucens* was taken are shown in Figs. 10 and 11. It occurs constantly in all but the coldest water of the sub-Antarctic Zone, though it may occur in that too as far south as the Antarctic convergence. It has never been taken south of the convergence. It occurs also in a narrow belt of the coldest water of the subtropical Zone just north of the subtropical convergence.

Of the stations at which it was taken the three south-east of the Cape had the highest surface temperatures, that of the first of them, 20·1° C., being the highest. This is warmer water than they are usually found in, and their presence in it is accounted for by the shape of the subtropical convergence in this region. To the west of the Cape it lies in 37° S, but to the south of it the Agulhas Current causes it to bend sharply southwards. Its position varies more here than elsewhere (except perhaps south of the Brazil Current), and a mixing of sub-Antarctic and subtropical waters takes place throughout a large area. But the area would not include the northernmost two of the three stations at which *E. lucens* occurred. Although they were far from the convergence to the south they were not so distant from it, and the waters of lower temperature in which *E. lucens* usually occurs, to the west.

Apart from this exceptional area the highest surface temperatures of the stations at which it was found were from 12 to 14° C., except for the nearest of those to the south-west of Western Australia where it was 16·12° C.

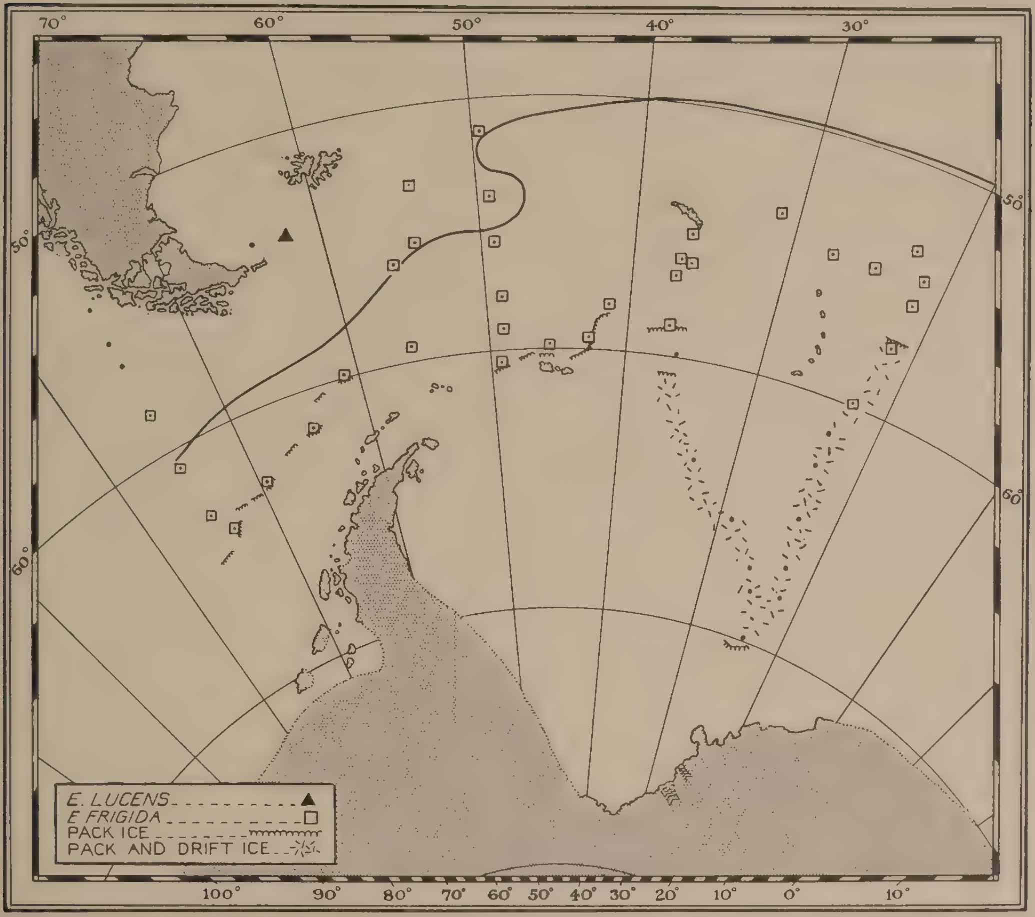


Fig. 10. Chart showing the occurrence of *E. lucens* and *E. frigida* at the stations made in the Falkland Sector in the summer of 1931–2. The thick line represents the Antarctic convergence.

The lowest surface temperature at which it was found, 5·02° C. at a station just north of the Antarctic convergence to the east of the Falkland Islands, is in another exceptional area; other warmer sub-Antarctic forms, e.g. *E. similis*, are found farther to the south here than elsewhere. Their presence is due to the unusually strong southward movement of sub-Antarctic water in the Falkland region. Elsewhere the lowest temperatures at which *E. lucens* was found were 6·5–7° C.

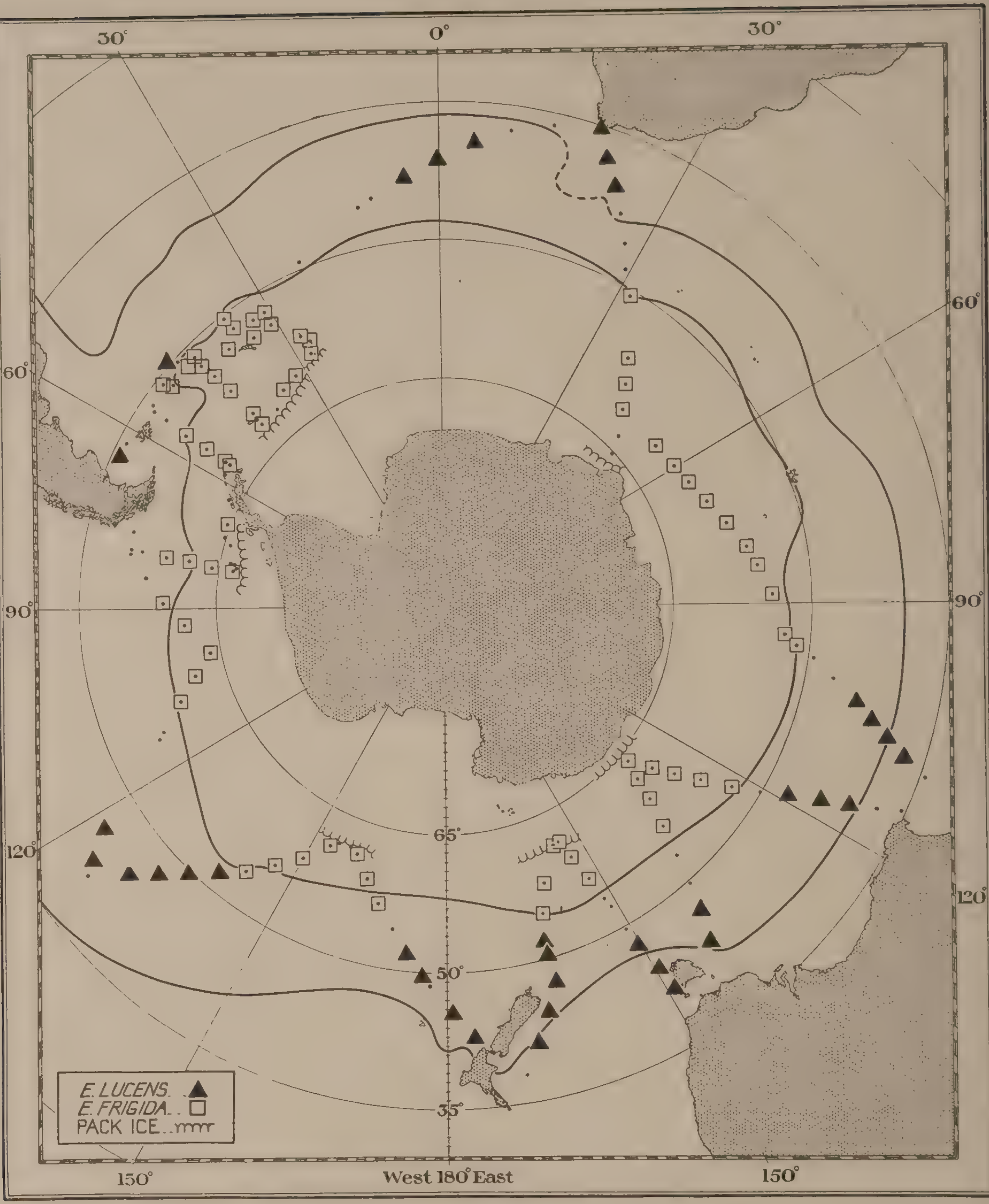

30°
0°
30°
60°
60°
90°
90°
120°
120°
65°
50°
35°
150°
West 180° East
150°
E. LUCENS. ▲
E. FRIGIDA. ☐
PACK ICE

Fig. 11. Chart showing the occurrence of *E. lucens* and *E. frigida* at the stations of the circumpolar cruises made in February to October 1932, and in the Falkland Sector in the summer of 1932–3. The inner of the two thick lines represents the Antarctic convergence, the outer the sub-Antarctic convergence.

Euphausia vallentini, Stebbing (Figs. 12–14, 30 *b*)

E. vallentini, Stebbing, 1900, p. 545, pl. xxxvii; Holt and Tattersall, 1906, p. 3; Tattersall, 1908, p. 13, pl. iv, figs. 4–6; Hansen, 1911, p. 30; 1913, p. 32, pl. v, figs. 1 *a–f*; Zimmer, 1914, p. 427; 1915, p. 178; Tattersall, 1924, p. 21; Illig, 1930, p. 499; Mackintosh, 1934, p. 76 *et seqq.*; Hardy and Gunther, 1935, pp. 217–19, fig. 94.
E. splendens (part), Sars, 1885, p. 80, pl. xiii, figs. 7–17.
E. patachonica, Colosi, 1917, p. 187, pl. xiv, figs. 11–14, pl. xv, figs. 15–20.

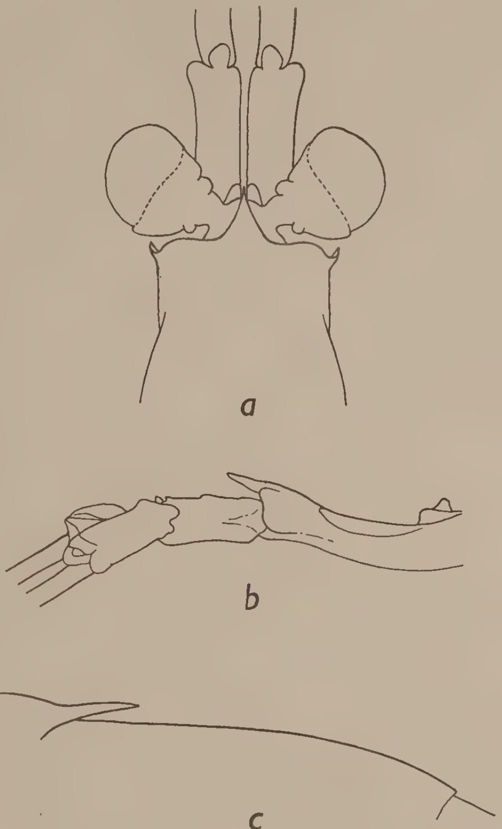


Fig. 12. *E. vallentini.* *a*, front part of carapace and first segment of antennules from above, × 12. *b*, left antennular peduncle from the side, × 15. *c*, median dorsal process of third abdominal segment, × 37.

Description. The carapace is not produced far forwards dorsally. The rostrum is a short sharp triangle about as long as or a little longer than broad; it is much more distinct than that of *E. lucens*. The anterior margin of the carapace is faintly convex behind each eye (Fig. 12 *a*). The gastric area of the carapace is moderately or sharply convex.

The first segment of the antennular peduncle has a very characteristic lobe: it is large, broad and rounded and projects horizontally above the second segment (Fig. 12 *a*, *b*). In larger specimens, but not in smaller, there is a small rounded or tooth-like vertical projection on the upper surface of the second segment at the inner distal corner, and a smaller tooth-like projection near the outer distal corner. There is a high dorsal keel on the third segment; the part seen from the side is strongly rounded above and nearly vertical in front.

There is a short thin mid-dorsal process from the posterior margin of the third abdominal segment (Fig. 12 *c*); rarely it is absent.

The copulatory organ of the male is very similar to that of *E. lucens* and *E. frigida* but easy to distinguish from them (Fig. 30 *b*). The proximal process is considerably longer and heavier than the terminal; its membranous expansions differ in appearance like those of *E. lucens*, the foremost having striations not possessed by the hindermost, but they are less unequal in size, and the foremost reaches more nearly as far forward as the hindermost; there is a small tooth on the outer side of the distal end of the process between the expansions as in *E. lucens*. The secondary process or spine on the proximal process is wider, more blade-like, than in *E. lucens*. The terminal process is bifid at the end, the inner of the two branches stronger than the outer and either a little longer than it or of the same length; the inner branch may have on its inner side a small blunt projection or tooth. The end of the lateral process is strongly curved but more widely so than that of *E. lucens*; it carries on the curve a strong tooth which points in the same direction as the end of the process. In the axil of that tooth on the hinder side there is always a tiny projection.

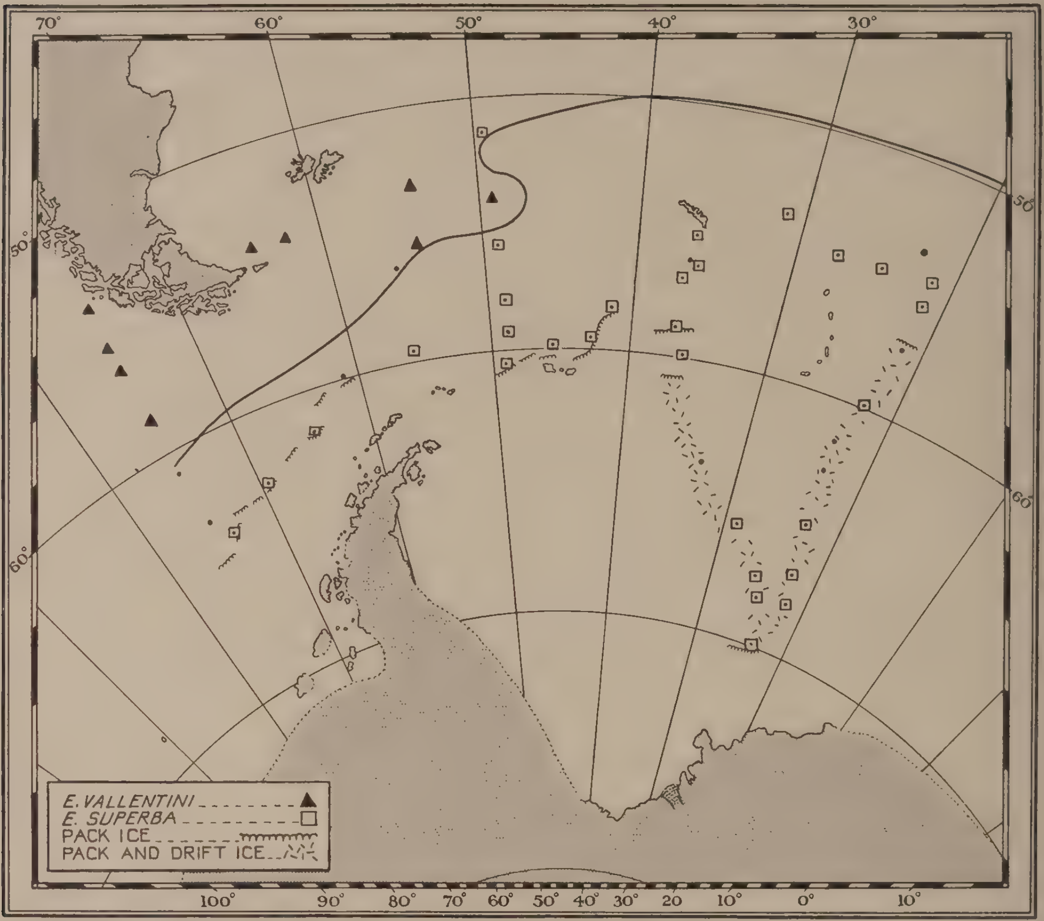
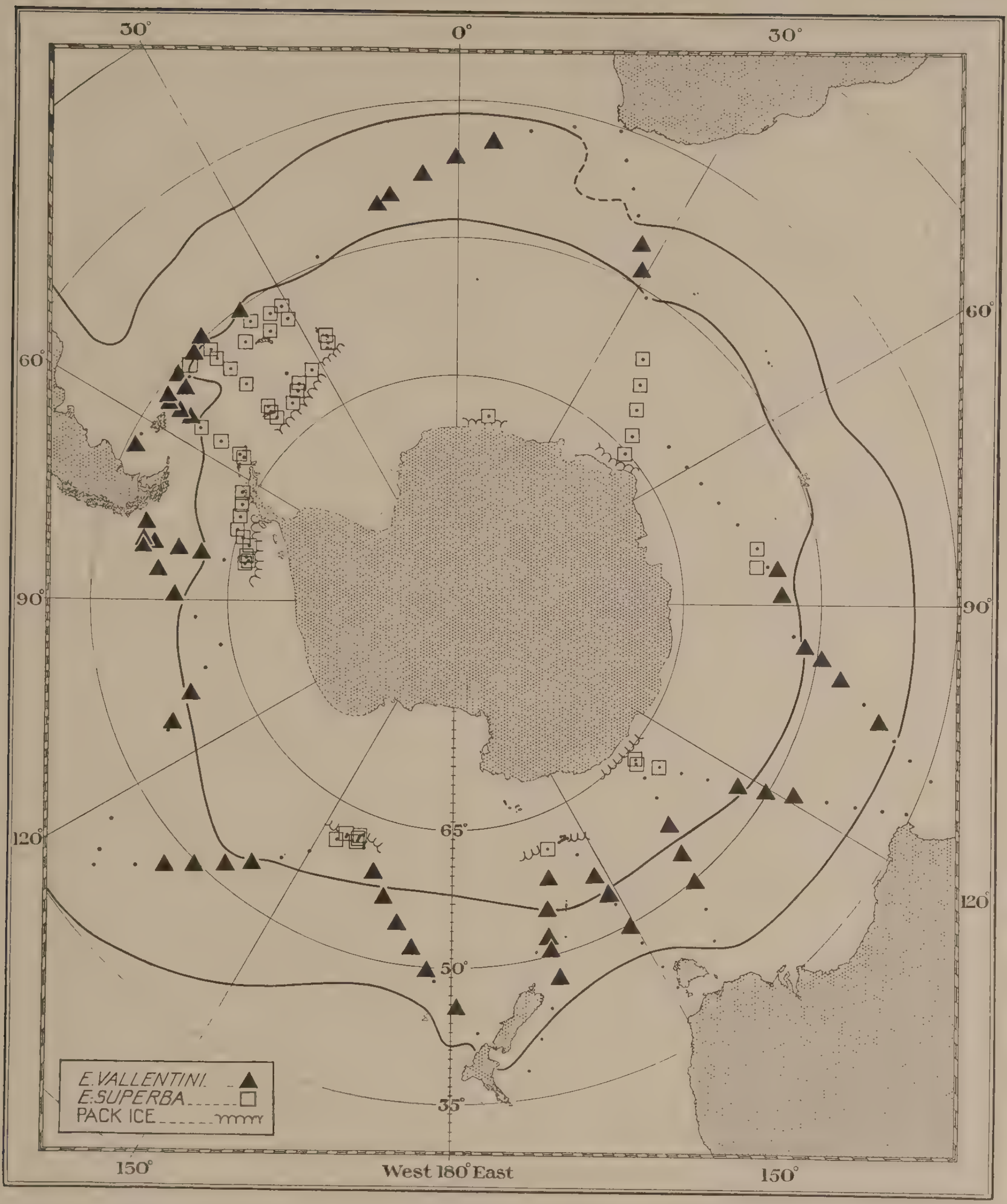


Fig. 13. Chart showing the occurrence of *E. vallentini* and *E. superba* at the stations made in the Falkland Sector in the summer of 1931–2. The thick line represents the Antarctic convergence.

Over 1800 specimens, apart from larval forms, of *E. vallentini* have been measured. The largest male was 25 mm. long, the largest female 28 mm., but the vast majority of the specimens were less than 24 mm. in length. One male so small as 13 mm. and several females of 15 mm. were seen carrying spermatophores, i.e. were sexually mature at those lengths, but the usual size for sexually mature individuals is greater.


30°
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90°
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35°
150°
West 180° East
150°
E. VALLENTINI ▲
E. SUPERBA □
PACK ICE

Fig. 14. Chart showing the occurrence of *E. vallentini* and *E. superba* at the stations of the circumpolar cruises made in February to October 1932, and in the Falkland Sector in the summer of 1932–3. The inner of the two thick lines represents the Antarctic convergence, the outer the sub-Antarctic convergence.

The earlier larval stages of *E. vallentini* are not known; those from the second Calyptopis upwards are described later in this paper.

DISTRIBUTION. The stations at which *E. vallentini* was taken are shown in Figs. 13 and 14. It occurs throughout the sub-Antarctic Zone except for a narrow belt of the warmest water to the north. The highest surface temperature of any of the stations at which it was taken was 14·2° C., at the station south-west of the Cape on March 1, i.e. in summer. The stations at which it occurred in the Indian Ocean, Australian, and Pacific Ocean sectors were made in winter, and the surface temperature at the northernmost of them was lower, usually about 8° C.

It was found a little way south of the Antarctic convergence in winter only. The flow of Antarctic surface water to the north, strongest in summer when snow and ice are melting in the south, is considerably reduced in winter when new ice is being formed near the Antarctic coasts. Our observations near the convergence in winter suggest that the slowing up of the current leads to a southern movement of sub-Antarctic water at the surface; north of the convergence we found purely sub-Antarctic water, but the Antarctic water south of it was mixed with sub-Antarctic water. In this way *E. vallentini* becomes carried into the Antarctic Zone. The numbers taken there were small compared with those from the nearest sub-Antarctic stations. The lowest surface temperature at which the species occurred was 0·74° C. at the southernmost station at which it was found on the line south-east of New Zealand in early September; there was only one specimen.

Euphausia frigida, Hansen (Figs. 10, 11, 15 and 30 *c*)

E. frigida, Hansen, 1911, p. 27, fig. 9; 1913, p. 30, pl. iii, figs. 4 *a* and *b*, pl. iv, figs. 1 *a–d*; Zimmer, 1914, p. 427; Tattersall, 1924, p. 20; Rustad, 1930, pp. 33, 43, 46–54, figs. 27–34; Ruud, 1932, pp. 52–4; Rustad, 1934, pp. 13–18, 34 *et seqq.*; Mackintosh, 1934, p. 76 *et seqq.*; Hardy and Gunther, 1935, many references.
Euphausia sp., Tattersall, 1908, p. 14.
E. splendens, Calman, 1901, p. 23.
E. crystallorophias (part), Illig, 1930, p. 500, fig. 182.
Not *E. frigida*, Illig, 1930, p. 498.

DESCRIPTION. The front margins of the carapace are faintly convex, the rostrum is very short and triangular (Fig. 15 *a*).

A small triangular or rounded lobe projects forwards from the inner distal corner of the first segment of the antennular peduncle; it is difficult to see from the side. The third segment has a strong dorsal keel with, as seen from the side, straight upper and distal margins which meet nearly at a right-angle (Fig. 15 *b*).

The abdominal segments have no dorsal spines.

The male copulatory organ is very like that of *E. vallentini* and *E. lucens*, but there are differences which make it easy to distinguish it (Fig. 30 *c*). It differs from that of *E. lucens* and resembles that of *E. vallentini* in that the proximal process is longer than the terminal; it resembles both species in that the proximal process carries a blade-like secondary process or spine and in that it has two membranous expansions distally which differ from one another, the foremost having striations which are not present in the hindermost. The foremost expansion reaches a little farther forward (i.e. distally) than the hindermost. Between them, on the outer side of the distal end of the proximal process, there is a conspicuous tooth-like projection easy to see with a low magnification; it is in the position occupied by a very small tooth, which is often difficult to see under a high magnification if the membranous lobes are not so placed as to show it in profile, in *E. lucens* and *E. vallentini*. The terminal process is bifid at the extremity. The inner branch may be equal in length to or slightly longer or shorter than the outer; it is divided distally into two unequal lobes, the hinder shorter and smaller than the foremost. The outer branch is narrower than the inner, triangular or lanceolate in shape, and its hinder margin is finely serrate (Fig. 30*c* 2). The lateral process is sharply curved at the end and carries on the curve a strong tooth; in the axil of that tooth on the hinder side there is a small or very small projection.

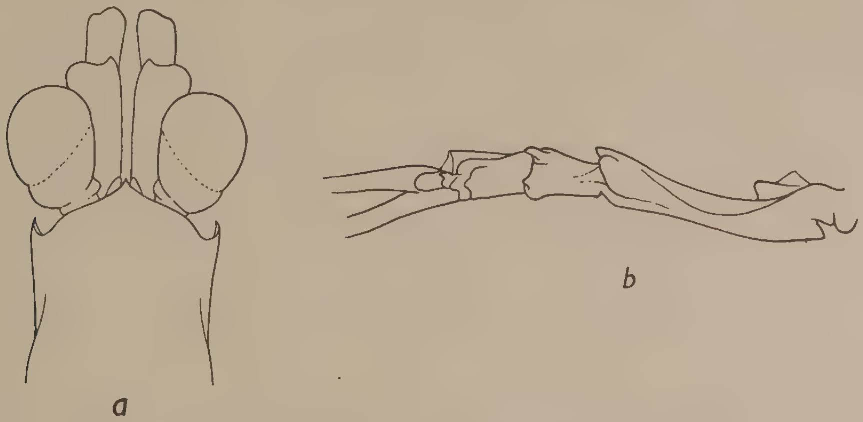

Fig. 15. *E. frigida*. *a*, front part of carapace and first segment of antennules from above, × 12. *b*, left antennular peduncle from the side, × 18.

Over 4200 specimens of *E. frigida*, apart from larval stages, have been measured. The largest males were 21 mm. long, the largest females 24 mm. In September and October some males and females only 11 mm. long, and many slightly larger, were found carrying ripe spermatophores, i.e. were sexually mature. The generation born the preceding season become sexually mature at this time before they are physically mature; they grow to full size a month or two later.

The larval stages of *E. frigida* from the second Calyptopis upwards are described later in this paper.

REMARKS. I am sure that Illig (1930, p. 498) is wrong in his only record of *E. frigida*, a female from subtropical water off the west coast of South Africa. He records none from the stations made by the 'Valdivia' in Antarctic water where one would expect that the tow-nets could not fail to take some. *E. frigida* was in fact obtained there. I was doubtful of Illig's records of *E. crystallorophias* (1930, p. 500, fig. 182) from, among other localities, deep water far from land in the Antarctic. Through the kindness of

Dr A. Schellenberg of the Zoologisches Museum, Berlin, I was allowed to examine the animals identified as such from St. 135 east-north-east of Bouvet Island, and from St. 145 north of Enderby Land. They were not *E. crystallorophias* but *E. frigida*; Illig's figure of the copulatory organ is certainly not that of *E. crystallorophias*: it is something like the organ of *E. frigida*.

Distribution. The stations at which *E. frigida* were taken are shown in Figs. 10 and 11. It occurs throughout the Antarctic Zone from the convergence in the north to the edge of the pack-ice in the south. Our stations in the drift- and pack-ice of the Weddell Sea show that it is not found among and under the ice—except that it occurred at the two northernmost stations, east of the South Sandwich Islands. At these two stations the surface and deep waters were warmer than at the other stations made near them; they were not so directly in the path of the Weddell Sea Current but were in eddies of warmer water.[1] In such latitudes in summer the loosening pack-ice may be carried over water already containing *E. frigida*.

The species occurred, but in much smaller numbers than in the Antarctic Zone, at a few sub-Antarctic stations just north of the convergence; one of them was to the south-east of New Zealand, the others to the south-west of Cape Horn and to the east of the Falklands. They are carried over with the small quantities of Antarctic water that may cross the convergence anywhere at the surface, more particularly in summer; or in a deeper layer by the Antarctic water that sinks below the sub-Antarctic, from which they regain the surface. These water movements across and beneath the convergence are particularly strong in that region, to the east of the Falklands, where *E. frigida* has been found most frequently to the north of its usual habitat.

Euphausia superba, Dana (Figs. 13, 14, 16, 30 *d*)

E. superba, Dana, 1852, p. 654, pl. lxiii, figs. 1 *a–o*; Sars, 1885, p. 84, pl. xiv, figs. 5–9; Holt and Tattersall, 1906, p. 2; Coutière, 1906, p. 8; Tattersall, 1908, p. 4, pl. i, figs. 1–12; Hansen, 1908, pp. 3, 7, pl. i, figs. 4 *a–m*; Zimmer, 1912, pp. 65–128, pls. viii–xiv, text-figs. 1–5; Hansen, 1913, p. 27, pl. iv, figs. 2 *a–g*; Tattersall, 1913, p. 875; Zimmer, 1914, p. 424; Hansen, 1915, p. 79; Tattersall, 1918, p. 6; 1924, p. 18; Illig, 1930, p. 497; Rustad, 1930, p. 39, figs. 20–26; Ruud, 1932, pp. 20–51, figs. 5–17; Rustad, 1934, pp. 11, 34 *et seqq.*; Mackintosh, 1934, p. 76 *et seqq.*; Hardy and Gunther, 1935, many references.
E. murrayi, Sars, 1885, p. 82, pl. xiv, figs. 1–4.
E. antarctica, Sars, 1885, p. 86, pl. xv, figs. 1–8.
E. glacialis, Hodgson, 1902, p. 236, pl. xxx, figs. 1–8.
E. australis, Hodgson, 1902, p. 238, pl. xxx, fig. 9.

Description. This species is the giant of the genus and may be distinguished from all others by the long terminal segment of the mandibular palp which is at least seven times as long as broad, whereas in all others it is short and stout, about three times as long as broad. The setae of the thoracic limbs are much longer than in any other species of the genus.

The carapace has a distinct cervical groove, and the part in front of it is faintly convex and keeled in the mid-dorsal line (Fig. 16 *a*). The front part is produced at the antero-lateral corners into strong projections one behind each eye. In old heavily chitinized males the projections are softened or disappear as such, because their margins have become turned upwards and backwards. The rostrum is short and triangular and may be a little shorter in the male than in the female. In old heavily chitinized males, and much more rarely in females, the lateral denticles of the carapace are reduced or wanting.

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[1] A single specimen of *E. triacantha* was found at each (p. 232).

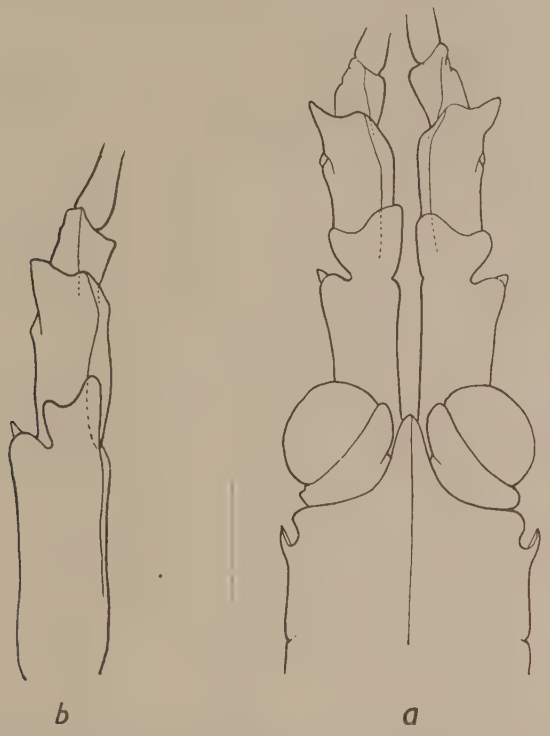

Fig. 16. *E. superba*. *a*, front part of carapace and antennular peduncles of female from above, × 10. *b*, left antennular peduncle of male from above, × 11.

The antennular peduncles differ a little in the two sexes, but they are very variable in both, as a comparison of the accounts and drawings of Sars (1885), Tattersall (1908), Hansen (1913) and Rustad (1930) shows. My description of them is based upon an examination of fresh material as well as upon these earlier accounts. In both sexes the characteristic structures are stronger in young specimens than in old.

The antennular peduncle of the male (Fig. 16 *b*) is somewhat stouter than that of the female (Fig. 16 *a*). The lobe of the first segment is wide and strongly vaulted; it is usually a little narrower than the second segment, but it may be as wide; its length varies from less than one-quarter to one-half the length of the second segment. Its shape is variable, but it is mostly longer on the inner side than the outer so that its distal margin is oblique; it is usually emarginate too. There may or may not be a short strong spine or a blunter tooth-like projection at the outer distal corner of the first segment of the peduncle. A wide lobe projects forwards from the upper surface of the second segment over the third. It may be as wide as the third segment and nearly half as long, its outer distal angle may be strongly produced forwards, outwards and downwards; a keel which runs the length of the inner side of the upper surface of the segment turns outwards distally to end where the lobe bulges outwards above the median line of the third segment. The lobe may in older specimens be much smaller and shorter, its distal margin straight, or it may be entirely wanting. The third segment has a high keel which may be wanting in old heavily chitinized specimens.

In the female the lobe from the end of the first segment of the antennular peduncle is usually bigger than in the male; it may be wider or narrower than, and anything from over one-half to less than one-third as long as, the second segment. As in the male its shape is variable, but it is usually much longer on the inner side than on the outer, so that its distal margin is oblique, and it is usually concave or emarginate. There may or may not be a spine or projection at the outer distal corner of the first segment as in the male. The lobe from the end of the second segment is usually bigger than in the male, its outer distal corner more strongly produced; but it is variable. It varies from being (most often) wider than the third segment to being narrower, and from being more than one-half to one-quarter of its length. The outer distal corner is usually strongly produced forwards, outwards and downwards so that it sometimes reaches nearly as far forward, on the outer side, as the end of the third segment. There are keels on the second and third segments as in the male. The lobe of the second segment and the keel of the third do not appear to disappear in old heavily chitinized females as they do in males.

The abdominal segments have no dorsal spines.

The male copulatory organ is as distinct from that of *E. crystallorophias* and those of *E. frigida*, *E. vallentini* and *E. lucens* as the former is from the three latter, but it is nevertheless of the same pattern as the four of them (Fig. 30 *d*). The proximal part of the terminal process is bent nearly at a right angle to the distal part, which is about three times as long. The basal part, or foot, is bigger than in *E. frigida*, *E. vallentini* and *E. lucens*, but the heel is not so sharp. The end of the process tapers and curls forwards; it is not bifid.

The distal two-fifths of the proximal process is bent inwards and carries two membranous expansions, one distally, the greater part of it lying on the hinder side of the axis of the process, and one on the foremost side immediately near the bend. The distal end of the latter touches the former. The foremost expansion is striated, that which is distal and for the most part hindermost is not. There is at first sight no secondary process such as occurs in the three species already described; none had previously been seen. But it is present in the majority of males, though not in all, as a spine bent forwards over the foremost expansion. It may be as long as that shown in the figure or very much smaller, one-third as long or less, or it may be entirely wanting: of thirty heavily chitinized males examined it was present in the left petasmas of twenty, absent from those of ten.

The lateral process is curved at the end; it carries no tooth or secondary process.

On the inner and front margin of the median lobe, beyond the end of the lateral process, there is always a small additional process; in one specimen there were two additional processes.

I have seen a very small spine-shaped process on the inner lobe in one or two specimens of *E. superba* (cf. p. 205).

REMARKS. This species, the largest, most interesting and most important of the genus, has been studied more closely by other members of the Discovery staff than by me. Hardy and Gunther (1935, pp. 208–15) have written of its great importance in the ecology of Antarctic seas and more particularly of its economic importance as the only food of Blue and Fin whales in the south; of its peculiar habit of swarming in dense shoals so that it becomes accessible to the whales in numbers large enough to satisfy them; and of its occurrence as larvae and adults in different seasons on the South Georgia whaling grounds. Fraser (1936) has published a very full description of all the larval stages—more complete, and based upon far larger numbers of specimens, than any previous account of the development of a Euphausiid. Dr H. E. Bargmann will shortly be publishing a description of the internal anatomy of the species and an account, based upon the enormous collection of specimens now available, of its life history beyond the larval stages and of its distribution throughout the Antarctic Zone.

Dr Bargmann has already examined a very large number and I am indebted to her for the following facts: females are usually a little larger than males but both may reach a length of 60 mm.; the smallest female with spermatophores that she has seen was 32 mm. long, the smallest ripe male 41 mm.

DISTRIBUTION. I shall not attempt to give a full account of the distribution of *E. superba* here: Dr Bargmann will give a better one, based on far larger collections than I am considering, in her forthcoming report (see above).

The stations at which it was taken in the commission of 1931–3 are shown in Figs. 13 and 14. It was found on every one of our visits to the ice-edge, whether in summer or winter, and at the majority of the stations made far into the drift- and pack-ice of the Weddell Sea in January, including the southernmost of them.

In the Falkland Sector, where our observations were for the most part made in summer, *E. superba* was found scattered throughout the Antarctic Zone nearly as far north as the convergence. It may be similarly distributed in other parts of the Antarctic in summer; we did not find it to be so in winter on our circumpolar cruises east-about from S. Africa to S. America (Fig. 14). To the south-east of Africa, approaching Enderby Land, small numbers of larvae and adults were found at Sts. 851–4, far away from the ice-edge; large numbers of adults and very large numbers of larvae were found at the ice-edge itself (St. 855). This was in April. At and near the ice-edge to the south of Australia, in May (Sts. 887–8), a few adults and many larvae were taken. At the ice-edge to the south of the sea between Australia and New Zealand, in June, many larvae but no adults were found (St. 912). The next catches were made in September at the ice-edge to the south-east of New Zealand; there were larger numbers of larvae and adolescents but no adults (Sts. 952–5).

Fraser (1936, pp. 137–143) has examined and discussed the larval and adolescent forms taken at these successive visits to the ice-edge in winter, and writes of them: "In April Calyptopis 3 and early Furcilia stages are most abundant, in May Calyptopis stages have disappeared and Furcilia 2 predominates, in June it is Furcilia 6 (the last Furcilia), and in September adolescent forms, which have the chief place."

Apart from the stations approaching Enderby Land it was at only one place far away from the ice-edge that *E. superba* was found: to the south-east of Kerguelen (Sts. 861–2). One adult and large numbers of larvae were taken there in late April. Our hydrological observations showed that at both of these stations there was colder Antarctic water deflected from the south by the submarine ridge that connects Gaussberg on the mainland with Kerguelen. Other typical ice-frequenting planktonic animals were found at these two stations, and not at the stations before and after them.

E. superba is sometimes found in small numbers to the north of the convergence east of the Falklands; a strong tongue of Weddell Sea water flows north to this region.

Fraser (1936, pp. 109–165) has discussed the distribution of *E. superba* of different ages, in terms of depth, latitude and nearness to ice, taking the records given above into account. In material collected at other times he has found the Metanauplius almost as far north as the convergence in the Falkland Sector and therefore considers that the adults spawn away from the ice. He shows that the Metanauplius to early Furcilia stages have a deep habit, spending most of their time in the southward-flowing warm deep current (see p. 201 of this paper), and he finds in this a reason for the concentration of young and adolescent *E. superba* near the ice-edge. "The habitat of the late Furcilia and early adolescents is at the surface and predominantly at the ice-edge. They will spread northwards in the northerly flowing surface water (see p. 201 of this paper) with the breaking up and drifting away of the field ice in the spring and summer" (p. 165). As they are carried northwards they will grow and become adult; they will spawn and the deep-living younger larval stages will be carried south. So it is supposed that, during its life-history, *E. superba* makes a vertical cycle, along an axis that is approximately longitudinal, in the Antarctic Zone.

Euphausia crystallorophias, Holt and Tattersall (Figs. 17 and 30 *e*)

E. crystallorophias, Holt and Tattersall, 1906, p. 3; Tattersall, 1908, pp. 9–12, pl. ii, figs. 1–10, pl. iv, fig. 10; Hansen, 1908, p. 6, pl. i, figs. 3 *a–c*; Zimmer, 1914, p. 426, pl. xxvi, figs. 60–4; Tattersall, 1918, p. 6; 1924, p. 19; Mackintosh, 1934, p. 76 *et seqq.*; Hardy and Gunther, 1935, p. 218.

Not *E. crystallorophias*, Illig, 1930, p. 500, fig. 182.

? *Euphausia* sp. (calyptopis larvae), Rustad, 1934, p. 25.

DESCRIPTION. The carapace has a right-angled expansion or projection behind the upper part of each eye (Fig. 17 *a*). The margins between these projections and the rostrum are concave; the rostrum is long and sharp and reaches as far forward as the front of the eyes. The carapace has a gastro-hepatic groove from which a nearly horizontal keel runs forward mid-dorsally to and along the rostrum.

There is no dorsal lobe at the distal end of the first segment of the antennular peduncle as in the other species described; there is a short sharp spine, difficult to distinguish among the setae, on the outer distal corner (Fig. 17 *a*, *b*). The dorsal keel of the third segment is well developed and of the same shape as that in *E. frigida* but perhaps a little lower.

The abdominal segments have no dorsal spines.

The male copulatory organ shows many differences from those of the four species already described, but it is on the same pattern (Fig. 30 *e*). In *E. lucens*, *E. vallentini* and *E. frigida* the terminal process has a wide and somewhat foot-like base, the toe forming the point of attachment, the heel being free on the outer side; in *E. superba* the basal part of the process is bent nearly at a right angle to the distal part. The terminal process of *E. crystallorophias* is straighter and its base but little wider than the rest of it; but there is on the outer side, near the base and pointing back towards it, a blunt protuberance. The end of the process is divided into two very unequal parts. That which is the hinder- and outermost is by far the larger; it is long and tongue-like and curled forwards, and its inner edge is serrate. The other part is finger-like, curved at the end, and lies within the larger as though protected in its curl.

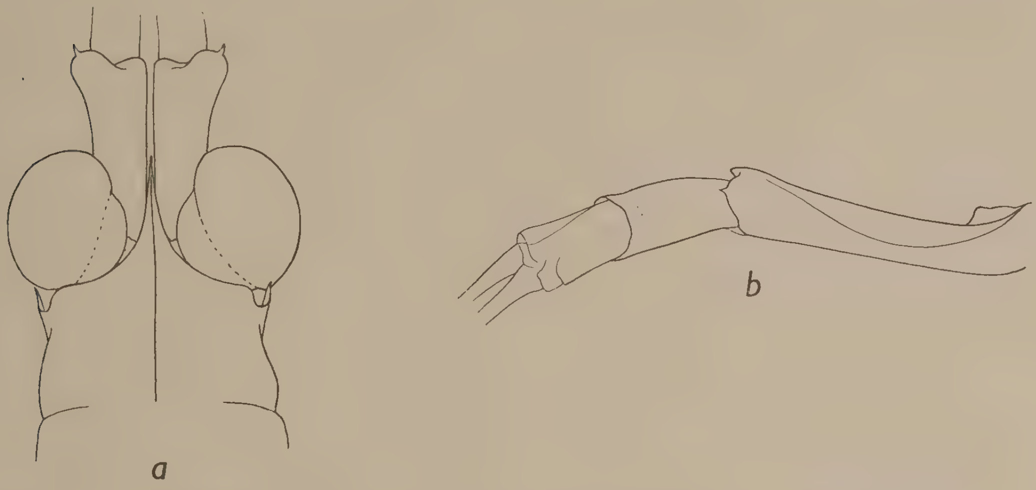

Fig. 17. *E. crystallorophias.* *a*, front part of carapace and first segments of antennules from above, × 12. *b*, left antennular peduncle from the side, × 14.

The proximal process has a secondary process as do those of the four other species (though it is reduced, and may be absent, in *E. superba*). The inner membranous part of it is expanded so that its edge is convex; it is also serrate. As in the other four species there are at the end of the proximal process in *E. crystallorophias* two membranous expansions, one behind and one before, the latter striated the former not, but their proportions and shapes are very different. The foremost expansion is very small and set comparatively far back on the process, the middle of its base opposite the secondary process. The hindermost and distal expansion is big. The proximal parts of its lower edges (which are uppermost in the figure) are serrate; the serrate parts are not continuous but are separated by a gap and lie in two different planes.

The end of the lateral process is shaped somewhat like a cargo hook; it has no tooth on the distal curve.

I have not measured large numbers of this neritic species as I have of the others which are oceanic. Tattersall, who examined the big collections of the Discovery (National Antarctic) and Terra Nova Expeditions, says in the first of his two reports (1908, p. 11) that the largest adult specimens of both sexes measure 32 mm.; in the second report (1924, p. 19) he records a length of 33 mm.

Tattersall (1908, p. 11, pl. ii, figs. 8–10) has given figures and a very brief account of a Calyptopis, a Furcilia and a Cyrtopia; but nothing is known of the variety of Furcilia forms which occur and of which among them are dominant.

REMARKS. Zimmer's careful description and drawings of the copulatory organ (1914, p. 426, pl. xxvi, figs. 60–64) do not agree with mine, and are taken from an immature individual; I have seen that stage of development. My description is based on specimens taken from one part of the Antarctic only, the west coast of Graham Land; but Dr Gordon has allowed me to examine an adult male, from the British Museum collection, taken from the other side of the continent, from the Ross Sea, and its copulatory organ was identical with those of my specimens.

I think that none of Illig's records (1930, p. 500, fig. 182) is correct. His figure of the male copulatory organ is certainly not that of *E. crystallorophias*; it is most like *E. frigida*. Through the kindness of Dr Schellenberg of the Zoologisches Museum, Berlin, I was able to examine his specimens from St. 90, WNW of Cape Town, St. 135, ESE of Bouvet Island and St. 145, NW of Enderby Land. I could not determine the single female or immature specimen from St. 90, but it was certainly not *E. crystallorophias*; the eight specimens that I saw from St. 135 were *E. frigida*, one male and seven females; the three females from St. 145 were *E. frigida*. His other records are from off the African coast where *E. crystallorophias* cannot occur, or from deep water in the Antarctic where it is very unlikely to be found (see below). Rustad (1934, pp. 41–3) has given a list of the "most remarkable" of Illig's records of Euphausians.

DISTRIBUTION. I found this species in only one of the net hauls examined during the second commission of the 'Discovery II', and that was from a station in shallow water, 304 m., in the western entrance to the Bransfield Strait. During the previous commission Dr Kemp found it at fourteen stations, one of which was on the south side of the Bransfield Strait and the others in the Bellingshausen Sea. Of these all but two were near the land, the west coast of Graham Land, and in shallow water—the depths were between 177 and 604 m. The other two stations (Sts. 563 and 579, *Discovery Reports*, IV, pp. 122–5) were in deep water some considerable distance from land and shallow water. Both were between 66½ and 70° S and 79 and 79½° W, and the depths were 3875 and 4056 m. At each of them only one small specimen was taken.

The specimens taken in abundance by the National Antarctic (Discovery) and British

Antarctic (Terra Nova) Expeditions were found in shallow water in the Ross Sea;[1] those of the Belgian Expedition from roughly 70° S $82\frac{1}{2}$° W in the Bellingshausen Sea near, if not in, shallow water; those of the Deutsche Südpolar Expedition from or from very near shallow water off Kaiser Wilhelm Land.

The species is thus neritic and circumpolar. Single specimens have been found on two occasions far from land, but this must be exceptional: none was found in our stations north of the South Shetlands, nor in those in the Weddell Sea, nor in those nearest to the land on our visits to the ice-edge during the circumpolar cruises in 1932.

Euphausia hanseni, Zimmer (Figs. 18, 28 *a*)

E. hanseni, Zimmer, 1915, pp. 180–2, figs. 38–41; Illig, 1930, p. 503.

Description. The rostrum is strong and long, reaching as far forward as the front of the eyes or farther, but not so far as the end of the first segment of the antennular peduncle (Fig. 18 *a*). The gastric area of the carapace has a strongly convex keel, easy to see with the naked eye, which runs to and down the rostrum; there is no notch in this keel as there is in those of *E. spinifera* and *E. longirostris*. On either side, behind the upper part of each eye, the anterior margin of the carapace is produced into a

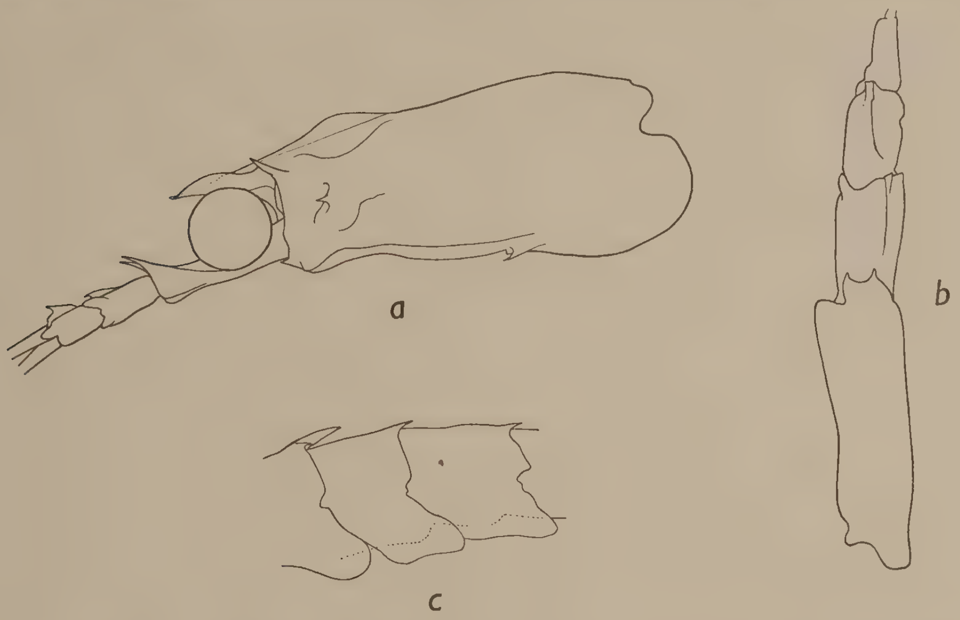

Fig. 18. *E. hanseni*. *a*, carapace and antennular peduncle from the side, × 12. *b*, left antennular peduncle from above, × 17. *c*, third to fifth abdominal segments from the side, × 5.

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[1] While this paper was in the press the 'Discovery II' visited the Ross Sea, going as far south as the Barrier (January, 1936). Mr J. W. S. Marr reports that "*E. crystallorophias* is the dominant euphausian in the neighbourhood of the Barrier and the Victoria Land coast. Dense swarms were seen in the Bay of Whales." He thinks that it may form the food of Minke whales (*Balaenoptera acutorostrata*, Lacépède) which are abundant in the Ross Sea.

forwardly and upwardly projecting spine, the post-ocular spine. On either side of the carapace near the anterior end there is a low mound-like projection, from the end of which a strong sharp spine points forwards; these are the hepatic spines. The carapace has one pair of lateral denticles set a little above the lower margin; immediately below it there is an angle in the margin which Zimmer has incorrectly described as a second denticle.

The lobe at the end of the first segment of the antennular peduncle is large and strong and points upwards and forwards above the second segment; it is narrower than the second segment and about one-third its length (Fig. 18 *a*, *b*). Its distal end is divided by a wide semicircular depression into two sharp and equal points. On the inner side of the dorsal surface of the second segment there is a keel, low proximally, high and produced into a sharp point distally; on the upper outer distal corner there is a very thick and blunt protuberance. The third segment has a high keel, the front part of it cut away so as to give it a peculiar and characteristic shape; a keel of a similar shape occurs in *E. eximia*, *E. recurva*, *E. gibboides*, *E. fallax* and *E. mucronata*.

The terga of the first and second abdominal segments are produced into small wide rounded projections mid-dorsally, that of the second wider and more rounded than the first. There is a strong compressed spine-like process from the third segment and smaller spine-like processes, not compressed, from the fourth and fifth segments (Fig. 18 *c*). The hind margins of the terga of the posterior abdominal segments are not deeply incised as they are in *E. spinifera* and *E. longirostris*.

The terminal process of the male copulatory organ has a heavy foot-like base, strongly arched, the heel big and high (Fig. 28 *a*). The shaft of the process is nearly straight. Near the end it divides into a shorter blunt heavily chitinized part, bent a little outwards, and a longer flatter blade-like part, with thin walls, bent a little inwards. The distinction between the parts can be seen on the front side before the point of actual bifurcation. The basal part of the proximal process is heavy and rounded, the distal part lighter and bent inwards. Its end is expanded into a large quadrangular plate lying in a vertical plane, most heavily chitinized along its lower margin (the uppermost in the figures). It is deeply incised in line with the axis of the process; the distal margin of the upper part (the lower in the figures) is crenated. The lateral process is hook-shaped and carries no secondary teeth or processes. On the median lobe, opposite the end of the lateral process and anterior to it, there is a small additional process.

This description is based on a collection of twenty-one males and twenty-five females from a net hauled horizontally at 200 m. at St. 270, 13° 58½′ S, 11° 43½′ E, near Benguela on the west coast of South Africa. The males, all of which had spermatophores and were therefore sexually mature, varied in length from 19 to 25 mm.; the females, five of which carried spermatophores, varied in length from 19 to 27 mm.

None of the larval stages is known.

Distribution. Zimmer described the species from a number of females from an unknown locality. Illig records them from five points off the west coast of Africa, from Cape Bojador in 26° N to near Cape Town in 34° S; I have seen those from his

St. 74, WNW of Benguela. My own specimens came from near this locality (see above). So far then there is no record of this species but from the Atlantic off the west coast of Africa.

Euphausia spinifera, Sars (Figs. 19, 20, 28 *b*)

E. spinifera, Sars, 1885, pp. 93–5, pl. xvi, figs. 9–16; Hansen, 1911, p. 35; Zimmer, 1914, p. 429; Tattersall, 1924, p. 26; 1925, p. 8, pl. ii, fig. 5; Illig, 1930, p. 503.

E. schotti, Ortmann, 1893, p. 13, pl. vii, figs. 8 and 8 *a* (larva).

E. longirostris, Illig, pp. 504–7, figs. 183–190 (larval and post-larval stages).

Description. The rostrum is strong and long reaching forward beyond the front part of the eye but not to the end of the first segment of the antennular peduncle (Fig. 19 *a*). The gastric area of the carapace is faintly convex and is keeled in the mid-dorsal line. In the position occupied by the dorsal organ in the larval stages the keel rises into a short crest which is abruptly terminated in front by a notch easy to see with the naked eye; the keel runs some way down the rostrum. The carapace is produced into a strong post-ocular spine above each eye. On either side of the carapace near the forward end there is a mound-like projection giving rise to a hepatic spine similar to but blunter than that of *E. hanseni*. There is a single pair of lateral denticles set above an incision in the lower edge of the carapace.

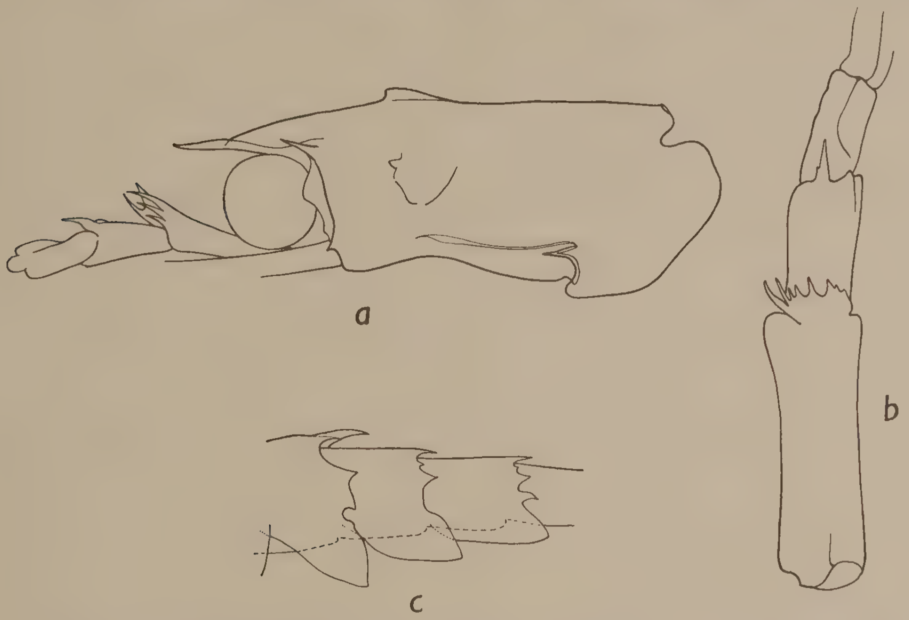

Fig. 19. *E. spinifera*. *a*, carapace and antennular peduncle from the side, × 14. *b*, left antennular peduncle from above, × 17. *c*, third to fifth abdominal segments from the side, × 8.

The lobe at the end of the first segment of the antennular peduncle is large and wide—wider than the second segment and wider distally than at the base; it is divided distally into a number of spines, usually four to six (Fig. 19 *a*, *b*). A strong flattened tooth-like projection rises over the third segment from the middle of the distal margin of the second; it is divided into two pointed processes distally, the inner much longer and bigger than the outer. A low keel runs dorsally along the distal part of the inner margin of the second segment. The third segment carries a high dorsal keel.

The terga of the first and second abdominal segments are produced into small wide rounded projections in the mid-dorsal line; there is a very strong compressed spine-like process from the third abdominal segment and smaller spine-like processes, not compressed, from the fourth and fifth segments. The posterior margins of the terga of the third, fourth and fifth segments are deeply incised (Fig. 19 *c*).

The terminal process of the male copulatory organ has a heavy foot-like base with a strong and high heel from which the shaft runs straight for three-quarters of its length (Fig. 28 *b*). At that point a short blunt process arises from its inner edge. Beyond it the distal quarter of the terminal process bends gently inwards and its tip may be curled forwards; the inner margin of this part is thin-walled. Of the twenty-five males in the collection only six were mature. In the left petasma of the smallest of them, 21 mm. long, the small blunt secondary process on the shaft of the terminal process was not present; it was present but very small in the right petasma.[1] The proximal process tapers from a fairly wide base to become narrow two-thirds of the way along it, and there bends sharply inwards and widens. Its extremity is expanded into a membranous plate the most of which lies in a plane between the horizontal and vertical, but the lower part (uppermost in the figure) is curled over backwards and a little upwards. The lateral process is hook-shaped; on the hind side of the bend there may be a very small projection. The median lobe has a small additional process.

Two hundred and thirty specimens were measured apart from larval and post-larval forms. The largest specimens of both sexes were 29 mm. long. Only one of the females, 24 mm. long, was recorded as carrying spermatophores, though not all were examined. There were only twenty-five males, and nineteen of them, including one 27 mm. long, had incompletely formed petasmas and were therefore immature. The smallest of the mature males was one 21 mm. long.

A series of larval stages from the second Calyptopis upwards is described on pp. 294–303. Ortmann's *E. schotti* and the young forms that Illig described as *E. longirostris* are larval stages of *E. spinifera*.

DISTRIBUTION. All the previous records of *E. spinifera* except Sars' and Illig's (see below), but including the series of larvae described by Illig as of *E. longirostris*, are from positions in the southern hemisphere that fall within the subtropical Zone.

It occurred at nearly all of our stations in the subtropical Zone and at one or two just south of the subtropical convergence in the warmer sub-Antarctic water (Fig. 20); at all of them the surface temperature was more than 11° C. But it was found, too, both as adults and larvae, at a group of four stations well within the sub-Antarctic Zone south of the Pacific in September where the surface temperatures were between 7·81 and 9·70° C. Only one specimen, a calyptopis larva, was taken at the southernmost and

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[1] Sars' figure shows that it was present in the specimen he examined, Tattersall's that it was absent from his.

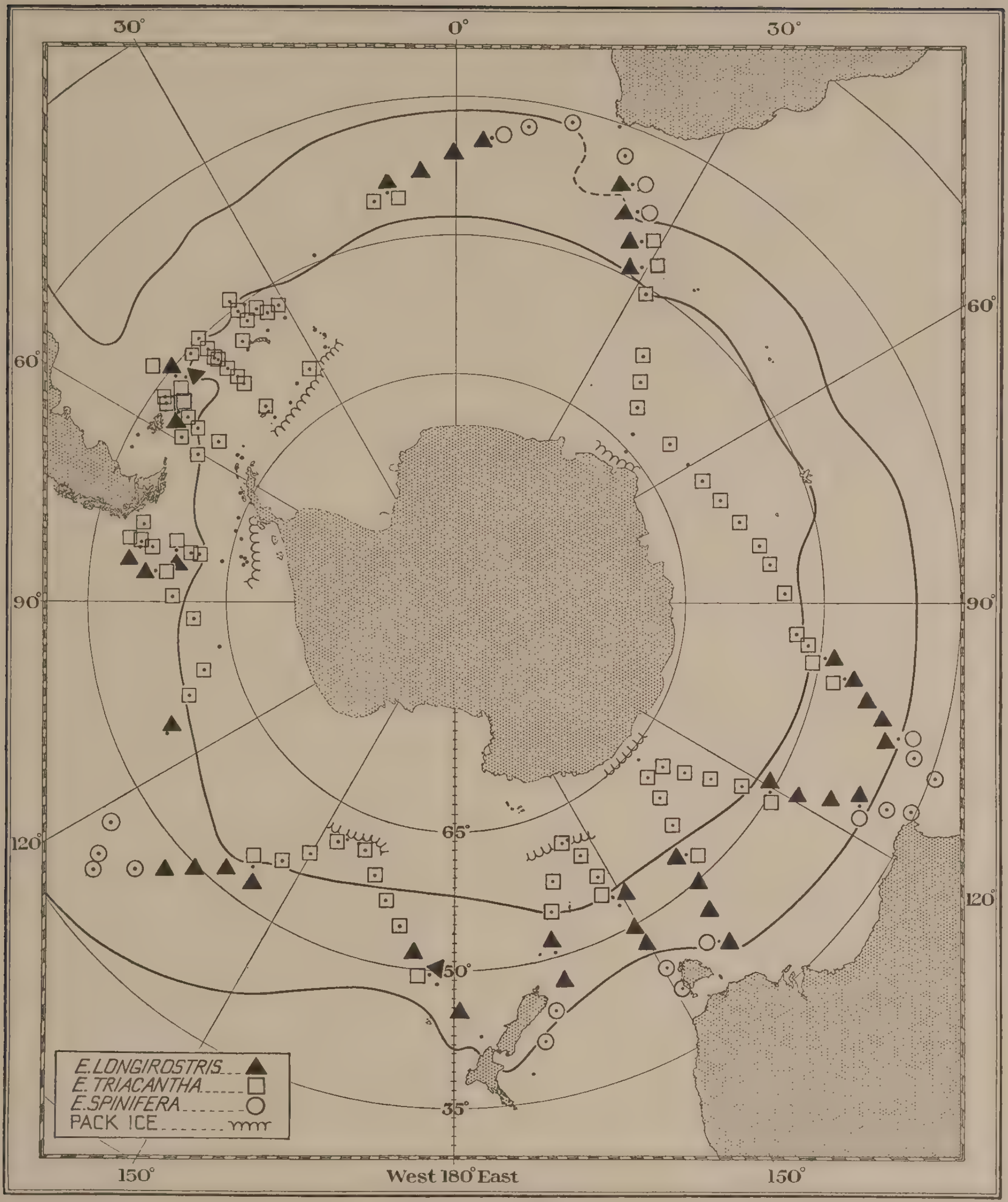
30°
0°
30°
60°
60°
90°
90°
120°
120°
65°
50°
35°
150°
West 180° East
150°
E. LONGIROSTRIS ▲
E. TRIACANTHA □
E. SPINIFERA ○
PACK ICE

Fig. 20. Chart showing the occurrence of *E. longirostris*, *E. triacantha* and *E. spinifera* at the stations of the circumpolar cruises February to October 1932, and in the Falkland Sector in the summer 1932–3. The inner of the two thick lines represents the Antarctic convergence, the outer the sub-Antarctic convergence.

coldest station. Some of Sars' four specimens came from near this locality in October and the others also from sub-Antarctic water—from 48° 18′ S, 130° 11′ E (see Tattersall, 1924, p. 27), south of Australia. There is no obvious explanation for the presence of *E. spinifera* in these places. The strikingly low salinities of the surface water at the four stations south of the Pacific, and at the Challenger St. 289 in the same area, suggest that there is a surface current of poorly saline water from the east. The hydrology of this part of the sub-Antarctic Zone is not well known, but the surface currents appear to be exceptional.

Illig's records of *E. spinifera* (1930, p. 503) include some from north-west of Cape Blanco on the west coast of North Africa. I have been allowed to examine the specimens by Dr Schellenberg of the Zoologisches Museum, Berlin, and I find that they are not *E. spinifera*. They are all immature (I could not find the male which was recorded), and I think they are *E. hanseni*.[1]

E. spinifera has not been found north of the subtropical Zone. In April and May 1931 a line of closely placed stations was made up the west-Atlantic along the 30th meridian to 15° N (Station List, 1929–1931, *Discovery Reports*, IV). Dr Kemp examined the Euphausians taken in the upper 200–300 m. of water by means of an oblique haul with a large stramin net at each of those stations. *E. spinifera* was taken only in the colder part of the subtropical Zone. A similar series of hauls was made down the west Atlantic in October of the same year, and I examined some, but not all, of the Euphausians in each haul. I found *E. spinifera* in the warmer part of the subtropical Zone only.

It is then a circumpolar subtropical species which is sometimes found some little distance within the sub-Antarctic Zone.

Euphausia longirostris, Hansen (Figs. 20–22, 28 *c*)

E. longirostris, Hansen, 1908, p. 4, pl. i, figs. 1 *a–c*; 1913, p. 35, pl. v, figs. 3 *a–d*; Tattersall, 1913, p. 877; Zimmer, 1914, p. 429, pl. xxvi, figs. 65 and 66; Tattersall, 1924, pp. 22–26, pl. i, figs. 1–7, pl. ii, figs. 1–4; Rustad, 1934, pp. 41–2; Hardy and Gunther, 1935, p. 207, fig. 94.
Peneus (?)—Zoëa, Dohrn, 1871, p. 375, pls. xxix and xxx, figs. 54–61 (larva).
Euphausia sp., Sars, 1885, p. 170, pl. xxxi, figs. 30 and 31 (larva).
Not *E. longirostris*, Illig, 1930, pp. 504–7, figs. 183–90.

DESCRIPTION. The rostrum is strong and very long, reaching as far forward as the

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[1] The youngest stage among them with a complete telson was one with three terminal spines. It differed in the following ways from the same stage of *E. spinifera* (compare p. 301): the frontal plate was a broad triangle, with denticulations on the margins so fine that they were difficult to see, and with a very small rostral spine; there was no trace of a posterior projection on the carapace; the third segment of the antennular peduncle carried on its upper side at the distal end a strong upwardly and forwardly projecting spine; the spine from the third abdominal segment was two-thirds the length of the fourth segment. The older specimens were early post-larval stages. The frontal plates of all were such as might be expected to develop from that of the furcilia with three terminal spines and unlike those of *E. spinifera* of the same size. All had a spine on the upper distal end of the third segment of the antennular peduncle; in the older of them it was obviously a part of the dorsal keel and gave it the characteristic shape it has in adult *E. hanseni* (Fig. 18 *a*). The larger had hepatic spines.

end of the first segment of the antennular peduncle (Fig. 21 *a*). The gastric area of the carapace is convex and strongly keeled in the mid-dorsal line; the keel rises to a crest, similar to but bigger than that of *E. spinifera*, in the position occupied by the dorsal organ in the larval stages. The carapace is produced into a pair of strong post-ocular spines behind and above the eyes. There are no hepatic spines, but in the position occupied by them in *E. spinifera* and *E. longirostris* there is a low mound-like projection rounded off on all sides but the anterior, where it ends in a more abrupt way. There is a single pair of lateral denticles set above an incision in the lower edge of the carapace.

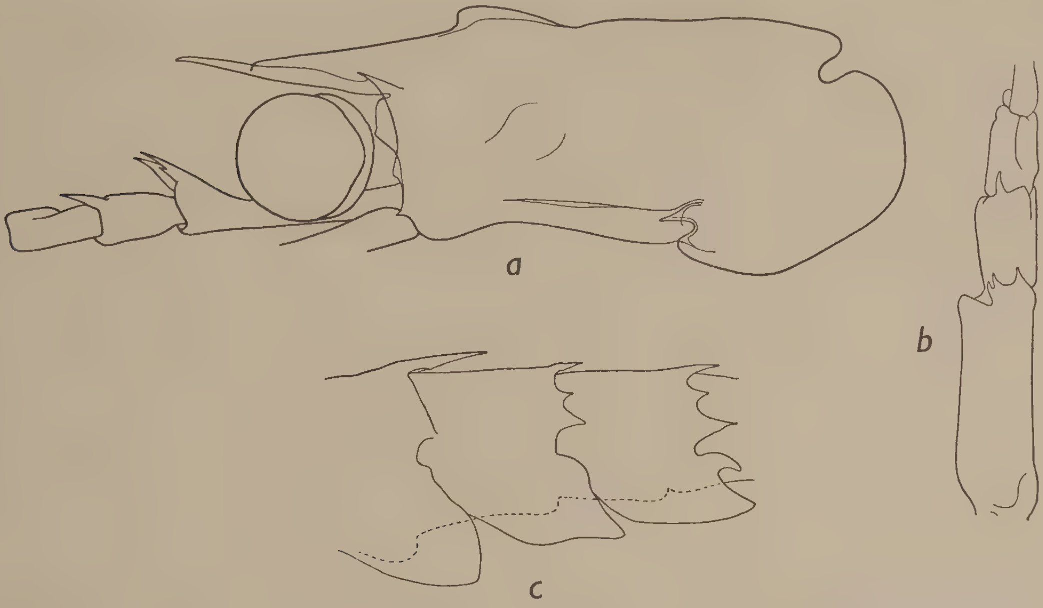


Fig. 21. *E. longirostris*. *a*, carapace and antennular peduncle from the side, × 13. *b*, left antennular peduncle from above, × 13. *c*, third to fifth abdominal segments from the side, × 8.

The lobe of the first segment of the antennular peduncle is large and strong but narrower than the second segment, above which it rises in an arch-like way (Fig. 21 *a*, *b*). Its distal end is divided into two nearly equal spines; a third and smaller spine may or may not arise lower down on the outer margin of the lobe—in one individual one antennule may have this spine and the other not; it is sometimes nearly as strong as the other two spines. A strong spine runs over the third segment from the middle of the distal margin of the second; there is a low keel along the distal part of the inner margin. The dorsal keel of the third segment is high and strong.

The terga of the first and second abdominal segments are produced into small, wide, rounded projections mid-dorsally; there is a very strong compressed spine-like process from the third abdominal segment and much smaller spine-like processes, not compressed, from the fourth and fifth segments. The posterior margins of the terga of the fourth and fifth segments are deeply incised (Fig. 21 *c*).

The terminal process of the male copulatory organ has a heavy foot-like base, bigger and heavier in proportion to the shaft than that of *E. spinifera* (Fig. 28 *c*). The shaft is bent a little inwards immediately above the foot. On the front and inner side near the distal end a short finger-like process, longer than that of *E. spinifera*, arises from it; the short part of the main process beyond is less heavily chitinized than that before and is often curled a little outwards. The proximal process is very similar to that of *E. spinifera* but there are differences: the proximal part is a little heavier and the intermediate part bent inwards at a greater angle to it; the distal part is not bent at so sharp an angle to the intermediate as in *E. spinifera*; the lower (upper in the figures) portion of the membranous expansion which curls backwards and upwards is considerably bigger. I find these differences to be constant. The lateral process is hook-shaped; it has on the hind side of the bend a very small and low forked process. The median lobe has an additional process.

Three hundred and seventy-five specimens were measured. The largest male was 33 mm. long, the largest female 34 mm. The smallest sexually mature male, carrying spermatophores and with fully formed petasma, was 20 mm. long, the smallest female carrying spermatophores 21 mm. long; they were taken in September.

A description of the larval stages from the second Calyptopis stage upwards is given on pp. 285–294. The larval and post-larval stages described by Illig as *E. longirostris* are actually *E. spinifera*; they are discussed on p. 294.

DISTRIBUTION. The stations at which *E. longirostris* were taken are shown in Figs. 20 and 22. All the previous records (they are summarized by Tattersall, 1924, p. 26) are from positions within the sub-Antarctic Zone, and the same is true of mine but for two south-east of the Cape. This is an exceptional region where sub-Antarctic water flowing north-east mixes with water from the Agulhas Current flowing in the opposite direction, and carries sub-Antarctic forms across the subtropical convergence.

E. longirostris is sometimes absent from the coldest water of the sub-Antarctic Zone, and it has never been taken in the Antarctic.

Euphausia triacantha, Holt and Tattersall (Figs. 20, 22, 23, 28 *d*)

E. triacantha, Holt and Tattersall, 1906, p. 4; Tattersall, 1908, p. 12, pl. iv, figs. 1–3; Hansen, 1913, p. 34, pl. v, figs. 2 *a–g*; Zimmer, 1914, p. 428; Illig, 1930, p. 503; Rustad, 1930, pp. 43, 54, figs. 35–37; Ruud, 1932, p. 54; Rustad, 1934, pp. 19–25; figs. 3–7, p. 34 *et seqq.*; Mackintosh, 1934, p. 76 *et seqq.*; Hardy and Gunther, 1935, many references.

DESCRIPTION. The carapace is expanded a little over each eye-stalk so that its antero-lateral margins are convex, but there are no post-ocular spines. The rostrum is long, strong and sharp, and reaches well beyond the eyes. The gastric area of the carapace has a high and arched keel which is continued down the centre of the rostrum. On either side of the carapace there is a low mound-like projection similar to but lower than those of *E. longirostris*; no hepatic spine arises from it. The single lateral denticle on either side of the carapace is placed very near the lower edge in which there is no incision. (Fig. 23 *a*, *b*.)

The lobe of the first segment of the antennular peduncle is strong and bifid, the inner

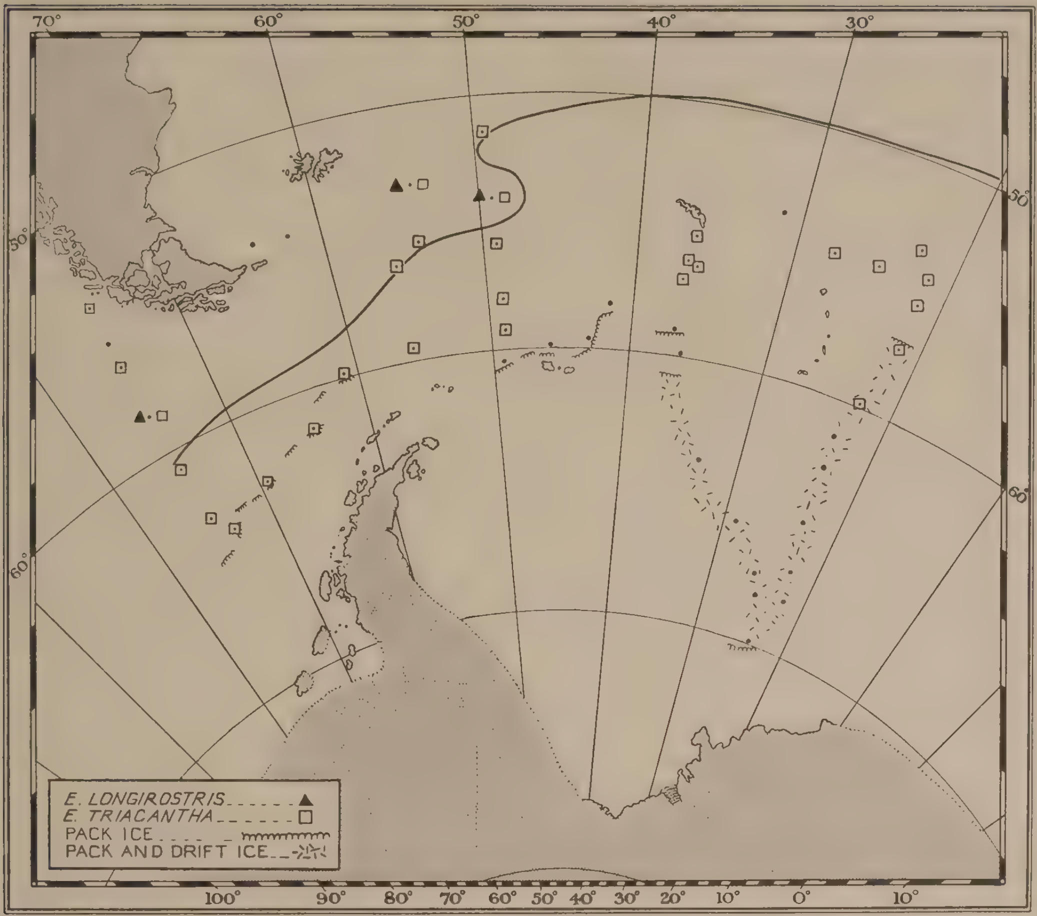

70°
60°
50°
40°
30°
50°
50°
60°
60°
E. LONGIROSTRIS ...... ▲
E. TRIACANTHA ...... ☐
PACK ICE
PACK AND DRIFT ICE
100°
90°
80°
70°
60°
50°
40°
30°
20°
10°
0°
10°

Fig. 22. Chart showing the occurrence of *E. longirostris* and *E. triacantha* at the stations made in the Falkland Sector in the summer of 1931–2. The thick line represents the Antarctic convergence.

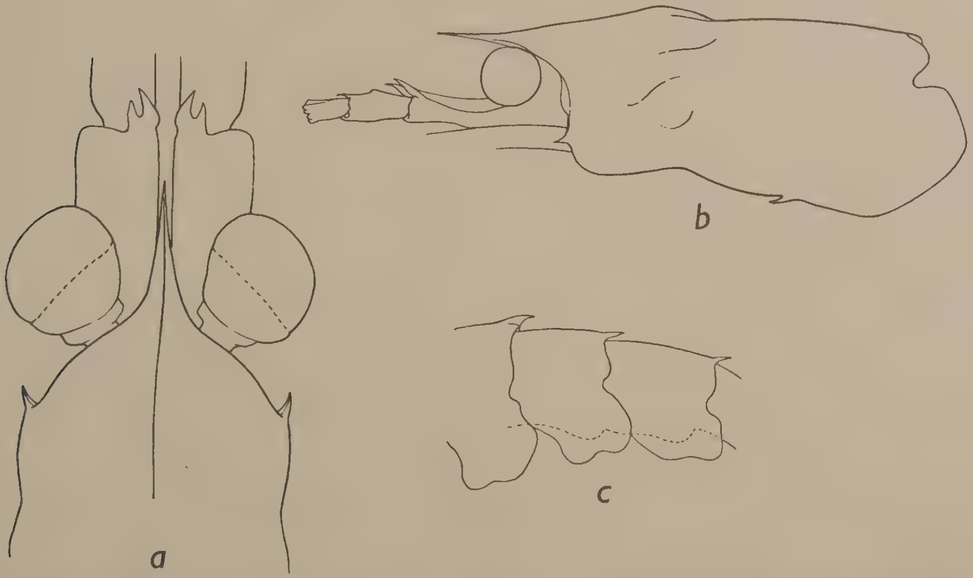


Fig. 23. *E. triacantha.* *a*, front part of carapace and first segment of antennules from above, × 12. *b*, carapace and antennular peduncle from the side, × 6. *c*, third to fifth abdominal segments from the side, × 6.

of its pointed branches stronger and longer than the outer, its distal end turned outwards. A tooth-like process runs forward above the third segment from near the middle of the distal margin of the second. The dorsal keel of the third segment is low (Fig. 23 *b*).

The terga of the first and second abdominal segments are produced into very small rounded projections mid-dorsally. There are strong spines from the third, fourth and fifth segments; all three are compressed, but the third is more strongly compressed and is stronger than the fourth and fifth. The hind-margins of the terga of the posterior abdominal segments are not deeply incised as they are in *E. longirostris* and *E. spinifera* (Fig. 23 *c*).

The terminal process of the male copulatory organ has a wide foot-like base with a high exaggerated heel, the end of it turned forwards towards the toe (Fig. 28 *d*). The whole process from the heel to the distal end is gently curved inwards and it tapers to a point. About half-way along it, measuring from the bottom of the heel, there is on the inner side a short finger-like structure not projecting so as to break the line of that edge of the process as seen from behind, but embedded or partly embedded in a sheath in its wall (Fig. 28 *d* 2). Before it the inner edge is thick-walled, but beyond it is very thin-walled, while the outer edge is thick-walled from the heel to the tip; so that the distal end of the process has a blade-like appearance, the cutting edge on the inner side.

The proximal process curves inwards a little less than half-way along it and outwards again near the end. Its proximal portion is only moderately thick. The hinder inner margin of the distal end is thick-walled but the process is faintly expanded and thin-walled on the outer front side, and the margin of the expansion is very finely denticulate. The lateral process is hook-shaped and has no secondary spines or projections on it. There is a small additional spine on the median lobe.

Over 1080 specimens were measured apart from larval stages. The largest male was 41 mm. long, the largest female 40 mm., but on the whole the females were slightly larger than the males. The smallest ripe male, with fully formed petasma and carrying spermatophores, was 26 mm. long, though not all were examined. The smallest female carrying spermatophores was 24 mm. long.

A description of the larval stages from the second Calyptopis upwards is given on pp. 277–285.

Distribution. The stations at which *E. triacantha* was taken are shown in Figs. 20 and 22. It occurs throughout the ice-free water of the Antarctic Zone and in a narrow belt of the sub-Antarctic.

It may occur at the edge of the pack-ice but it is more frequently absent from it; it is probably very unusual to find it some way inside the pack-ice as we did at two stations to the east of the South Sandwich Islands in January. Only one was found at each (*E. frigida* was found at them too, see p. 216). At both stations the surface and deeper waters were warmer than at those near them; they were not so directly in the path of the Weddell Sea Current but were in eddies of warmer water. *E. triacantha* is not on the whole found so far south as *E. frigida*. The lowest surface temperature at which it was taken was − 1·76° C. at one of the stations near the ice-edge south-east of New Zealand in September.

It occurs north of the Antarctic in the coldest water of the sub-Antarctic Zone. The highest surface temperature at which it was taken was 9·05° C. at the northernmost of the two stations south of the mid-Atlantic, and only two specimens were found there. It is not usually found in such warm water. Two specimens were taken unusually near the northern limit of the sub-Antarctic Zone to the south-east of New Zealand. The salinity of the surface water showed that there was a strong movement of sub-Antarctic water to the north along the 2000-m. contour line east of New Zealand, towards the Chatham Islands.

There are reasons, which I hope to give in a later paper, for believing that *E. triacantha* breeds only in the narrower part of its range, in the sub-Antarctic, and that as it develops it is carried into the Antarctic Zone by the southward flowing warm deep current.

Euphausia similis, Sars (Figs. 24–26)

E. similis, Sars, 1885, p. 79, pl. xiii, figs. 1–6; Ortmann, 1893, p. 12; Coutière, 1906, p. 7; Hansen, 1913, p. 29, pl. iv, figs. 3 *a–e*; Zimmer, 1914, p. 425; Hansen, 1915, p. 80; 1916, p. 642; Tattersall, 1924, p. 18; 1925, p. 7; Illig, 1930, p. 498.

Description. The anterior part of the carapace is produced on either side to form an obtuse projection behind the upper part of each eye (Fig. 24 *a*). The rostrum is strong and sharp and reaches as far forward as, or a little farther forward than, the eyes. The front part of the carapace is arched and keeled and the keel runs out along the rostrum (specimens with deformed rostra are not uncommon—see below).

A strong and conspicuous bifid lobe rises arch-like, forwards and upwards, from the inner part of the distal margin of the first segment of the antennular peduncle; the inner of the two forks is the longer and it is curved outwards, the outer may point outwards but it is straight (Fig. 24 *a*, *b*). The inner distal corner of the upper margin of the second segment is produced into a short, blunt, tooth-like process; it is the end of a low keel which runs along the inner side of the upper surface of the segment. There is a shorter and blunter projection on the outer distal corner. The third segment has a strong dorsal keel which, seen from the side, appears to start about one-third of the way along the segment; its upper margin is arched, its front margin oblique.

The hinder margin of each of the first and second abdominal somites is produced mid-dorsally into a very small triangular or rounded projection which can be seen in profile by pressing away the tergum of the somite behind it. The hinder margin of the third somite may have a wider, rounded and less obvious projection.

The terminal process of the male copulatory organ has a foot-like base with a strong high heel (Fig. 25 *a*). The shaft runs straight and tapers gradually towards the end, which is turned sharply forwards and inwards. On the inner and forward side just before the end there is a large and blunt projection of a complicated structure; it seems to be of thin walls held out by heavy bars and struts of chitin.

The distal part of the proximal process is bent inwards, nearly at a right angle to the

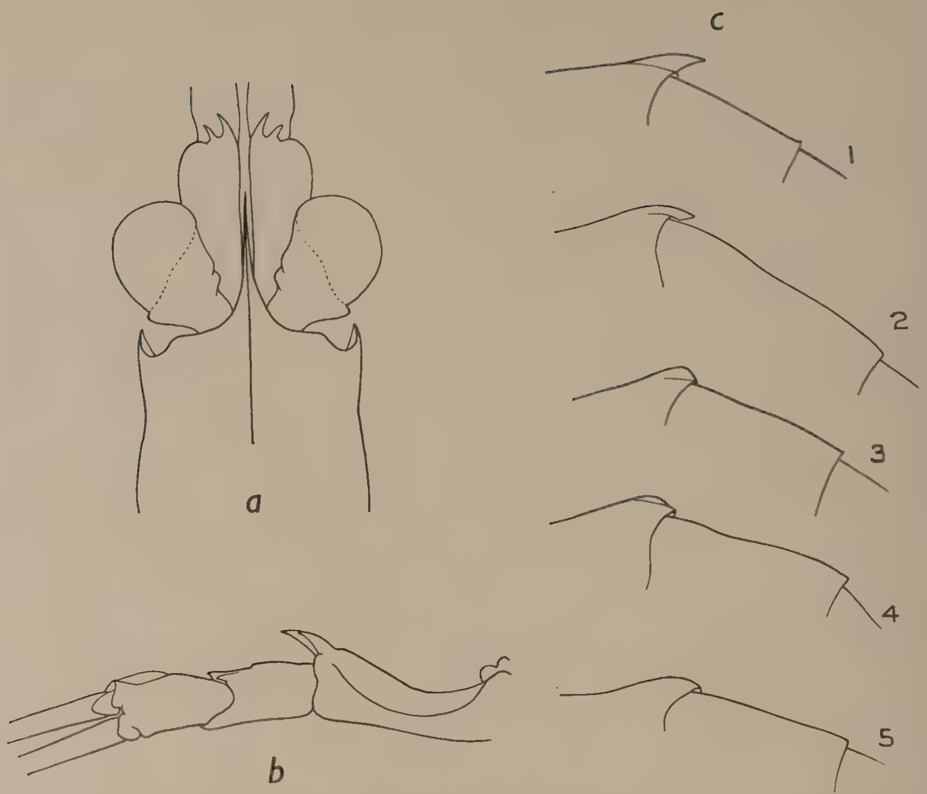


Fig. 24. *E. similis.* *a*, front part of carapace and first segment of antennules from above, × 19. *b*, left antennular peduncle from the side, × 14. *c*, var. *armata* showing the degree of development of the process on the third abdominal segment in five individuals, × 14.

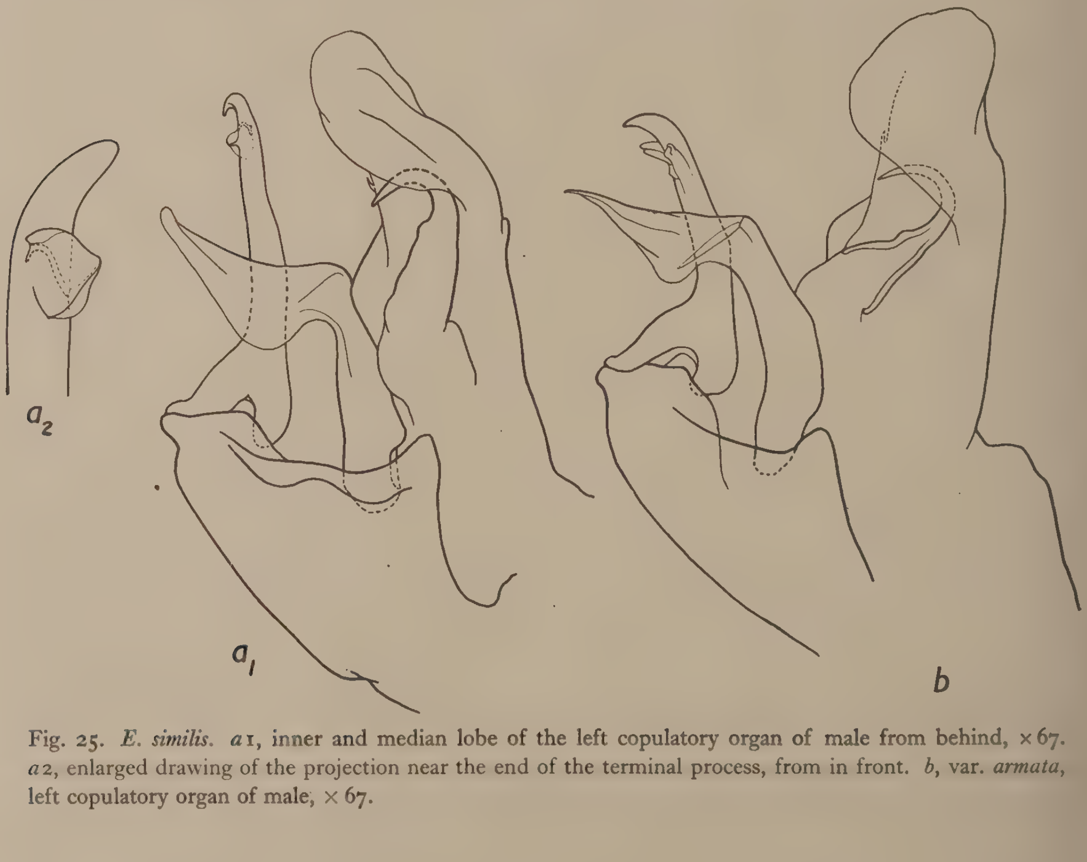
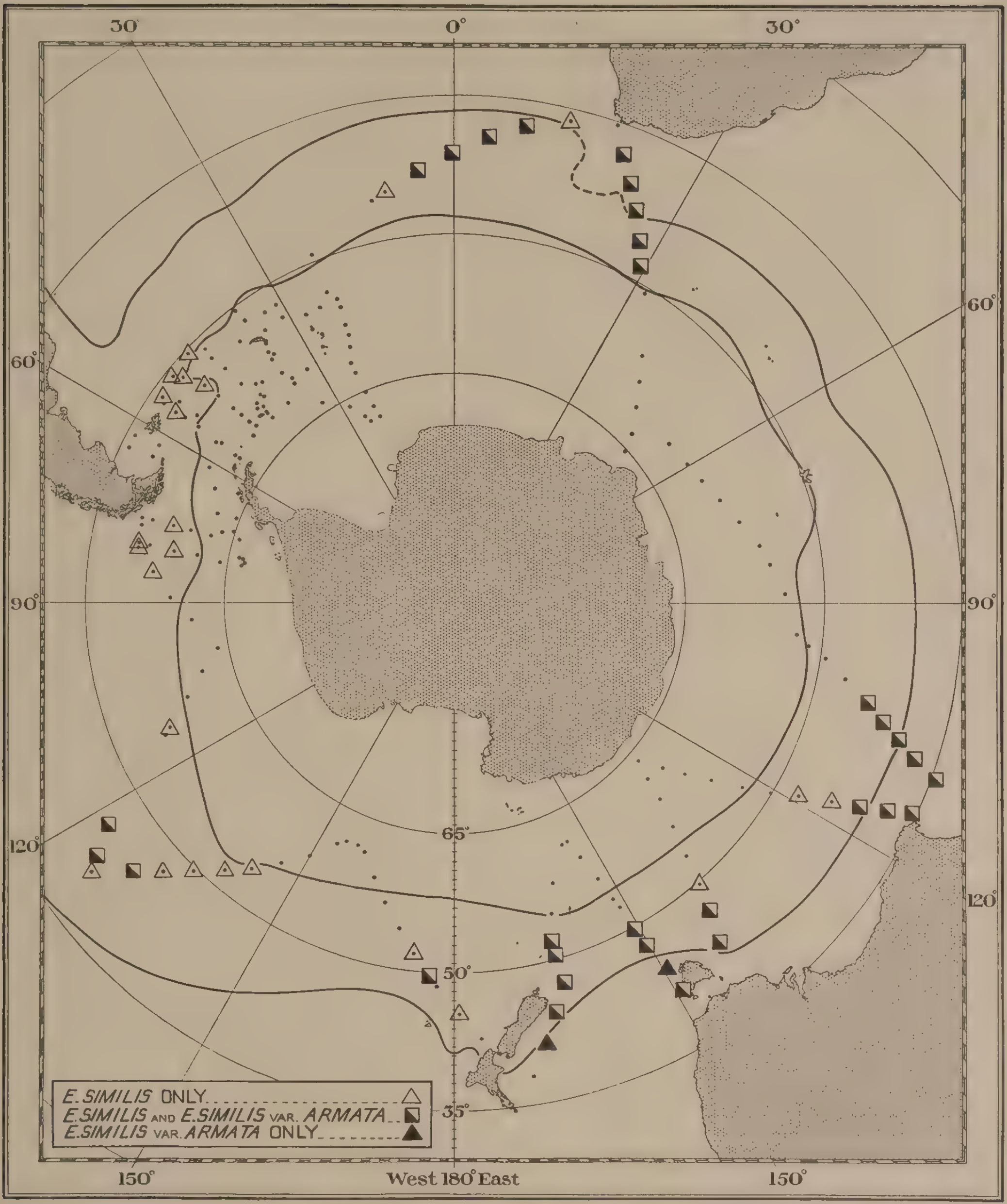


Fig. 25. *E. similis.* *a* 1, inner and median lobe of the left copulatory organ of male from behind, × 67. *a* 2, enlarged drawing of the projection near the end of the terminal process, from in front. *b*, var. *armata*, left copulatory organ of male, × 67.


30°
0°
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120°
120°
65°
50°
35°
150°
West 180° East
150°
E. SIMILIS ONLY △
E. SIMILIS AND E. SIMILIS VAR. ARMATA ◪
E. SIMILIS VAR. ARMATA ONLY ▲

Fig. 26. Chart showing the occurrence of *E. similis* and *E. similis* var. *armata* at the stations of the surveys of the Falkland Sector in the summers of 1931–2 and 1932–3, and of the circumpolar cruises February to October 1932. The inner of the two thick lines represents the Antarctic convergence, the outer the sub-Antarctic convergence.

6-2

proximal part, and expanded into a membranous plate which lies in a vertical plane. The proximal part is widest near the base; there is a definite angle in the outer margin at the widest point, whereas the inner margin is straight.

The lateral process is hook-shaped with no secondary teeth or processes. There is a small additional process on the median lobe.

The largest specimens of *E. similis* seen, both male and female, were 33 mm. long; the smallest female with spermatophores was 19 mm., the largest male with an incompletely formed petasma 24 mm. long.

None of the larval stages of *E. similis* has been described as such, but I think that the "Furcilia larva—Stage 1" described by Tattersall as of *E. longirostris* (Tattersall 1924, pp. 22–3, pl. i, fig. 1) is really *E. similis*. I have taken one similar to it and specimens of two later stages of the same species (see p. 286).

Distribution. The stations at which *E. similis* was taken are shown in Fig. 26. It is the most variable of the species described in this paper and has a much wider range than any of the others. Its southern limit is in all meridians the Antarctic convergence; although it may occur immediately north of it it is usually absent from the coldest part of the sub-Antarctic Zone. It is never found in the Antarctic.

It has been recorded from just south and from north of the equator in the Atlantic: Ortmann (1893) describes one specimen from the South Equatorial Current and Illig (1930) two specimens from north-west of Cape Blanco. I have examined the latter; one was about 5, the other between 5 and 6 mm. long and I could not recognize either as *E. similis*, though I could not be sure that they were not. Illig records the species too from west of Angra Pequena, about 26° S, in the east Atlantic; I have seen some of his specimens and found them to be *similis*. On the first of our two lines of stations in the west Atlantic extending as far as 15° N, which are described on p. 228, *E. similis* was found as far north in the subtropical Zone as 33° 47¾′ S, but no farther; on the second line it was not found so far north. For these reasons I feel doubtful of Ortmann's record from the South Equatorial Current. I cannot feel sure that the species has been shown to extend farther north in the Atlantic than some way into the subtropical Zone.

It has been recorded from farther north in the Indian Ocean and in the west Pacific: Illig (1930) records it from near the Seychelles, the Amirante Islands, the Maldive Islands, the Chagos Archipelago, Sumatra and Cocos Island in the Indian Ocean; Hansen (1915) from as far north as Japan and (1916) from near the Philippines in the west Pacific.

The other records of its occurrence are from the sub-Antarctic or subtropical regions of the southern hemisphere.

Euphausia similis var. armata, Hansen (Figs. 24 *c*, 25, 26)

E. similis var. *armata*, Hansen, 1911, pp. 24–6, fig. 7; Tattersall, 1924, p. 19; 1925, p. 7; Illig, 1930, p. 498.

E. similis var. *lobata*, Zimmer, 1914, p. 425, pl. xxvi, fig. 59.

Description. Hansen described the variety *armata* as being distinguished from the parent species by having the third abdominal segment "carinated posteriorly in the median line and produced into a compressed, somewhat short, but very conspicuous, acute process". I have found that the process may be very variable in size and shape; it varies from being low, rounded and inconspicuous to being a large compressed spine pointing backwards over the fourth segment (Fig. 24 *c*). There is no doubt that Tattersall was right in regarding Zimmer's variety *lobata* as the same as Hansen's *armata*.

Specimens with the process spine-shaped are more common than those with a rounded process in the waters from which my material comes. I have re-examined, since identifying them at sea, 459 specimens of the variety *armata* drawn from thirteen different stations. 400 of them, drawn from all the stations, had the process on the third abdominal segment spined, forty-nine from six of the stations had the process rounded. Of the thirteen stations two were near the Cape, one south of the mid-Pacific, the others south of Australia. Those with the process rounded came from the stations south of Australia, but I have no doubt that the rounded process occurs throughout the range of the species in similar latitudes; I have seen it in specimens from the south-west Atlantic and from south-west of the Cape. Specimens with the rounded process occurred in the warmer of the thirteen stations and were most numerous in the warmest of them.

The greatest number of *E. similis* var. *armata* to be taken in one net was 265 in the oblique haul with a metre net from 117 m. to the surface at the station east of Tasmania. They were immature and there were no *E. similis* in the same net. (In the deeper net at the same station, a metre net fished obliquely from 315 to 120 m., there were four *E. similis* and twelve var. *armata*). One hundred of the specimens from the shallow net were examined to see how many had the process spined and how many rounded: the numbers were seventy-six and twenty-four, and their lengths were as follows:

Length in mm.	Numbers with process spined	Numbers with process rounded
16	—	1
17	—	5
18	—	6
19	6	3
20	25	5
21	21	4
22	17	—
23	7	—

I do not, however, think that whether the process is rounded or spined is a question of age; I have seen specimens only 10 mm. long with the process strongly spined.

The antennules of the var. *armata* with strongly spined processes have the characteristic structures more strongly developed than in *E. similis*: the keel on the second segment is higher and transparent, and the process at its end stronger and sharper; the process at the outer distal corner of the second segment is stronger; the dorsal keel on the third segment is higher and more arched.

There are small but constant differences between the male copulatory organs of *E. similis* and the variety *armata* (Fig. 25). The proximal part of the proximal process is more nearly equal in length to the terminal process in the variety *armata*. The processes were measured in the petasmas of ten specimens of each kind—the terminal process in a straight line from heel to tip, the first part of the proximal process in a straight line from the outer corner of the base to the outer corner of the "shoulder". The average of ten measurements showed the length of the first part of the proximal process to be 76·3 per cent of that of the terminal in *E. similis*, 91·1 per cent of it in the var. *armata*. (The lower and upper limits were in *E. similis*, 68 and 82 per cent, in the variety *armata* 81·8 and 102·4 per cent.)

The distal half of the terminal process is bent inwards in *armata*, not straight as in *E. similis*; the foot is heavier, the instep more arched; the shaft is shorter but thicker, the curved end heavier. There are distinct differences in the structure of the projection near the end and in the angle at which it projects. The first part of the proximal process shows differences too: the inner margin is curved; the outer margin is more convex and is without the definite angle near the base that it has in *E. similis*.

Every one of these differences is shown in Hansen's two drawings (1913, pl. iv, fig. 3 *c* and 1911, fig. 7).

The largest male of the variety *armata* was 26 mm. long, the largest female 28 mm. Only one female, 27 mm. long, was noted as carrying spermatophores; I have no doubt that they can be mature at a much smaller length. Some males 23 mm. long were mature.

Distribution. The variety *armata* was found together with *E. similis* at most of our stations in the warmer part of the sub-Antarctic Zone and the colder part of the subtropical. It was absent at many of the stations at which *E. similis* occurred in the colder sub-Antarctic (Fig. 26). Hansen (1911) records it from localities that lie either in the sub-Antarctic or subtropical Zone, and from 13° S, 103° E in the Indian Ocean; Zimmer (1914) and Tattersall (1924, 1925) from the subtropical or sub-Antarctic Zones; Illig (1930) from the subtropical Zone off South Africa and—the most northerly record—from near Ceylon.

Euphausia similis var. crassirostris, Hansen.

E. similis var. *crassirostris*, Hansen, 1910, p. 94, pl. xiv, figs. 2 *a–c*; Tattersall, 1925, p. 7; Illig, 1930, p. 498.

Remarks. Hansen described the variety *crassirostris* from three immature specimens in which the frontal plate and the gastric area of the carapace was vaulted, the frontal plate a little longer, the rostral process shorter than in the parent species. Although I have seen over 900 *E. similis* and nearly 900 var. *armata* I have not found any specimens of this kind.

But specimens with deformed or misshapen rostra are not uncommon. In them the rostrum may be: shorter than is normal; much shorter than normal and thick and blunt; or so entirely wanting that the margin of the carapace between the post-ocular projections is concave. In the more abnormal specimens the gastric area of the carapace is often uneven and misshapen. All the individuals with abnormal rostra were not recorded as they were taken and examined day by day at sea. Since then 250 specimens of *E. similis* from eight stations and 459 specimens of *E. similis* var. *armata* from thirteen stations have been re-examined; three of the former and twenty-two of the latter had misshapen or deformed rostra.

DISTRIBUTION. Hansen (1910) described the variety *crassirostris* from the waters of the Malay Archipelago; Tattersall (1925) has recorded it from off the Cape and Illig (1930) from near the Cape and the Maldive Islands.

THE RELATIONS OF THE SPECIES TO ONE ANOTHER

I believe that nine of the ten species described in this report form two natural groups and that, if it be supposed that the genus *Euphausia* arose in warm waters, the existence of these groups and the order of occurrence of their members show that the genus has colonized the cold southern waters along two distinct lines. Along one line the colonization has not been completed; although the southernmost member occurs in the ice-free water of the Antarctic Zone it does not appear to breed successfully there. Colonization has been completed along the other line; every niche has been occupied to the farthest south: there is a neritic species along the coasts of the Antarctic continent.

The two groups are:

(1) *E. hanseni.*
E. spinifera.
E. longirostris.
E. triacantha.

(2) *E. lucens.*
E. vallentini.
E. frigida.
E. superba.
E. crystallorophias.

The first of these has long been recognized as a natural group. It is Hansen's Group *d*.[1] In 1910 and 1911 he divided the genus into four groups as follows:

> Group *a*. Species with two pairs of lateral denticles on the carapace. No dorsal process on third to fifth abdominal segments.
>
> Group *b*. Species with a single (rarely no) pair of lateral denticles on the carapace. No dorsal process on third to fifth abdominal segments.
>
> Group *c*. Species with a single pair of lateral denticles on the carapace. A protruding acute dorsal process on third abdominal segment, but without any dorsal process—at most with a minute denticle (*E. mucronata*)—on fourth and fifth abdominal segments.
>
> Group *d*. Species with a single pair of lateral denticles on the carapace. A well-developed dorsal process on third abdominal segment and conspicuous dorsal denticles or processes on fourth and fifth segments.

Hansen (1911) wrote: "the first and the fourth (Groups *a* and *d*) are well separated from the others, while the second and third (*b* and *c*), separated exclusively by the existence or non-existence of a dorsal process on the third abdominal segment, are somewhat badly defined, because two species show individual or local variation as to

[1] Hansen included in his Group *d E. spinifera*, *E. longirostris* and *E. triacantha*. *E. hanseni* was described later by Zimmer who recognized that it belonged to the same group.

the existence of this process." I agree with Hansen, and I believe that Groups *a* and *d* are natural groups but that Groups *b* and *c* are not.

The best criterion for separating the species of *Euphausia* is the copulatory organ of the male. Those of Group *a* and those of Group *d* each show some characters which no others have.

The members of each group are shown in the table below.

Group *a*	Group *b*	Group *c*	Group *d*
E. krohnii	*E. lucens*	*E. vallentini*	*E. hanseni*
E. eximia	*E. frigida*	*E. similis* var. *armata*	*E. spinifera*
E. americana	*E. superba*	*E. lamelligera*	*E. longirostris*
E. recurva	*E. crystallorophias*	*E. distinguenda*	*E. triacantha*
E. mutica	*E. similis*	*E. sibogae*	
E. brevis	*E. tenera*	*E. mucronata*	
E. diomedeae	*E. pacifica*	*E. fallax*	
		E. gibboides	
		E. gibba	
		E. pseudogibba	
		E. hemigibba	
		E. paragibba	

GROUP *a*

Hansen has figured the copulatory organs of every species of Group *a*, and I have seen those of *E. americana*, *E. recurva*, *E. brevis* and *E. diomedeae* in specimens from the Discovery collections. In every one of the seven species the terminal process has near the end a slender thin-walled finger-like secondary process such as is not found in any other species of the genus. There is nothing so distinctive in the proximal process, but there is a general similarity between those of all: they have heavy bases and are more or less strongly curved; the distal ends are expanded and flattened, and the beginning of the expansion on the inner and hinder side is in each abrupt and marked by an angle or protuberance. The lateral process has no secondary tooth or spine.

It is interesting to consider some of the other characters by which these species are distinguished—the structures on the antennular peduncle. The lobe on the first segment is either pectinate or bifid (except that it is acute in the male of *E. recurva*). The second segment has on the distal end of the dorsal surface a pair of tubercles or spines one at each corner, a tubercle on the outer corner only, or no tubercles. There is no constant correlation between these two sets of characters, those of the first and those of the second segment, as the following table shows.

From the fact that these seven species have the peculiar and distinctive characters of two pairs of lateral denticles on the carapace and of a slender thin-walled secondary process near the distal end of the proximal process of the male copulatory organ, I conclude that they form a natural group within the genus. Because in this natural group the structures on the antennular peduncle—the lobe on the first segment, the spines or tubercles on the second—show considerable variation I think that for the purpose of showing natural relationships they are less reliable than the characters of the male copulatory organs.

	First segment		Second segment		
	Lobe pectinate	Lobe bifid	A pair of tubercles	One tubercle	No tubercles
E. krohnii	×	—	×	—	—
E. eximia	×	—	×	—	—
E. americana	×	—	—	—	×
E. recurva	—	×	×	—	—
E. diomedeae	—	×	×	—	—
E. mutica	—	×	—	—	×
E. brevis	—	×	—	×	—

Just as differences in antennular characters may mask, or at least not show specific affinities, so similarities in them may either correspond with true affinities or give the appearance of affinity where there is none; though it is no doubt more probable that they would do the former than the latter. I believe both to be illustrated in Hansen's *gibba* group, the four species *E. gibba*, *E. pseudogibba*, *E. hemigibba* and *E. paragibba* (Hansen, 1910). He wrote (1912, p. 245): "*E. gibba* is closely allied and very similar to *E. pseudogibba*, *E. hemigibba* and *E. paragibba*. These four species are in reality so similar in general aspect, in shape of rostrum, size of eyes, lobe of first antennular joint, etc., that a close examination is necessary in order to separate them. As pointed out in the *Siboga Report* the male copulatory organs of the first pleopod afford excellent specific characters, and it may be added that these organs in *E. gibba* differ strongly from those in the three species mentioned. . . ."[1] They differ so strongly that there can be little doubt that *E. gibba* is not related to them (Fig. 27). The copulatory organs of *E. pseudogibba*, *E. hemigibba* and *E. paragibba* are so unlike those of any others and, despite strong

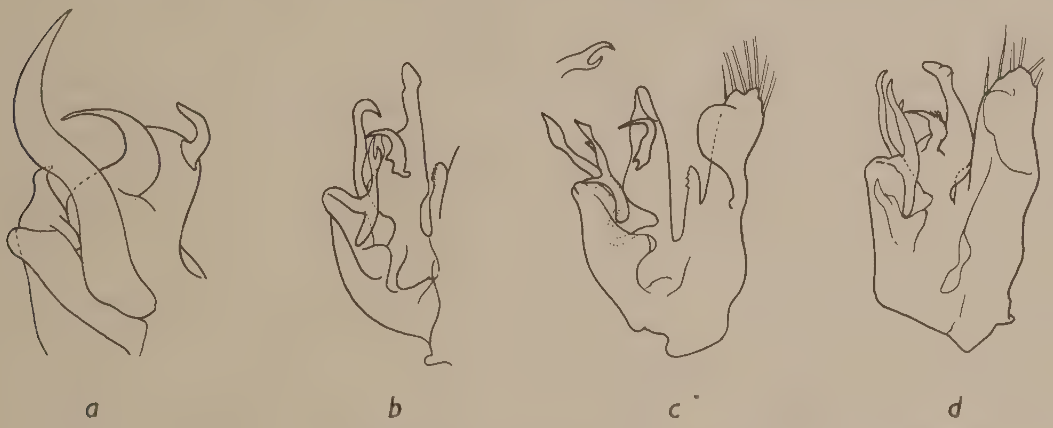

Fig. 27. Male copulatory organs of the species of the *gibba* group. *a*, *E. gibba*; *b*, *E. pseudogibba*; *c*, *E. hemigibba*; *d*, *E. paragibba*; after Hansen.

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[1] And, as Hansen recognized, from those of any other species of *Euphausia*.

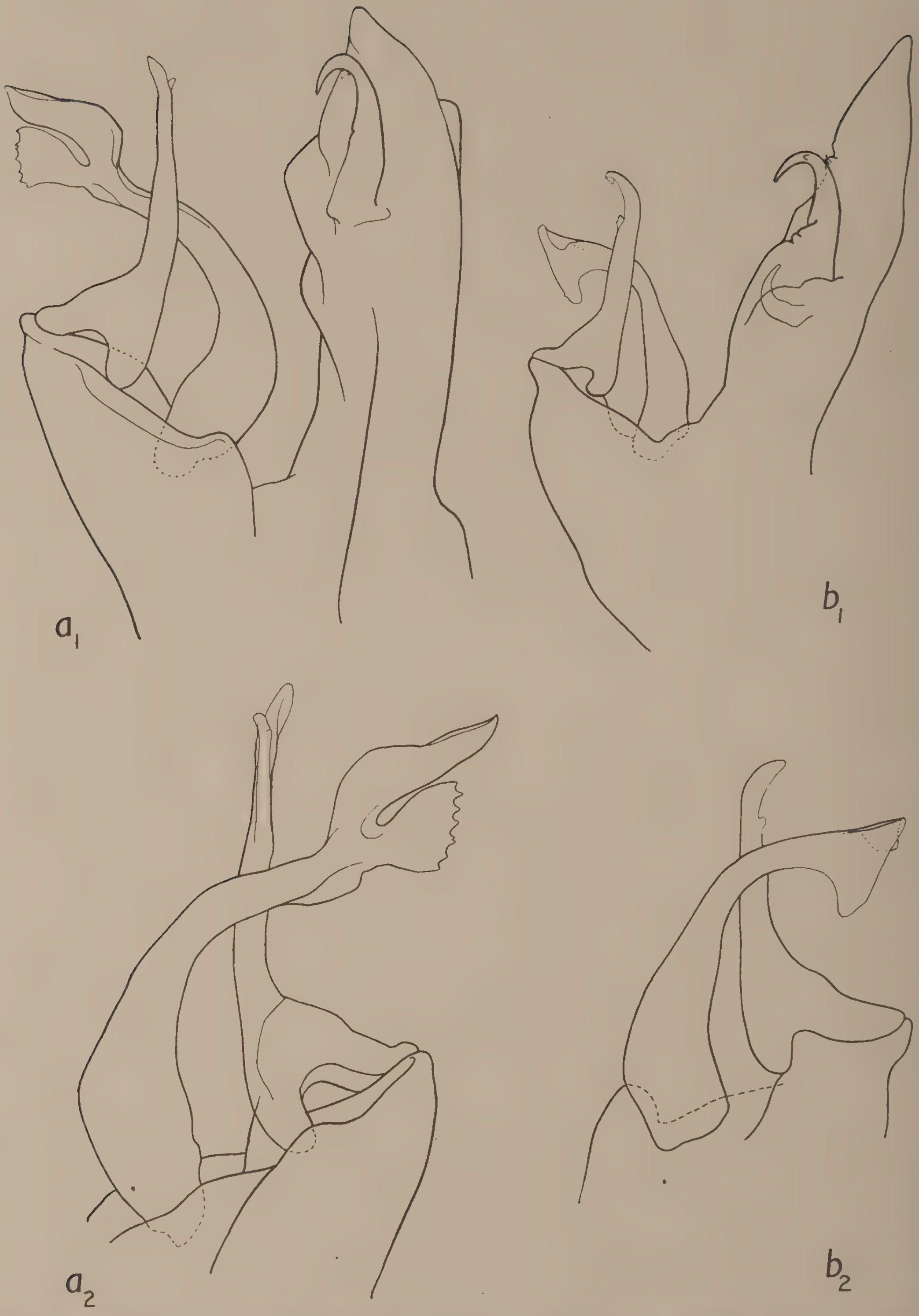

Fig. 28. Male copulatory organs of the left side of the species of group *d*. *a*, *E. hanseni*: 1, inner and median lobes from behind, × 100; 2, terminal and proximal processes from in front, × 154. *b*, *E. spinifera*: 1, inner and median lobes from behind, × 60; 2, terminal and proximal processes from in front, × 110.

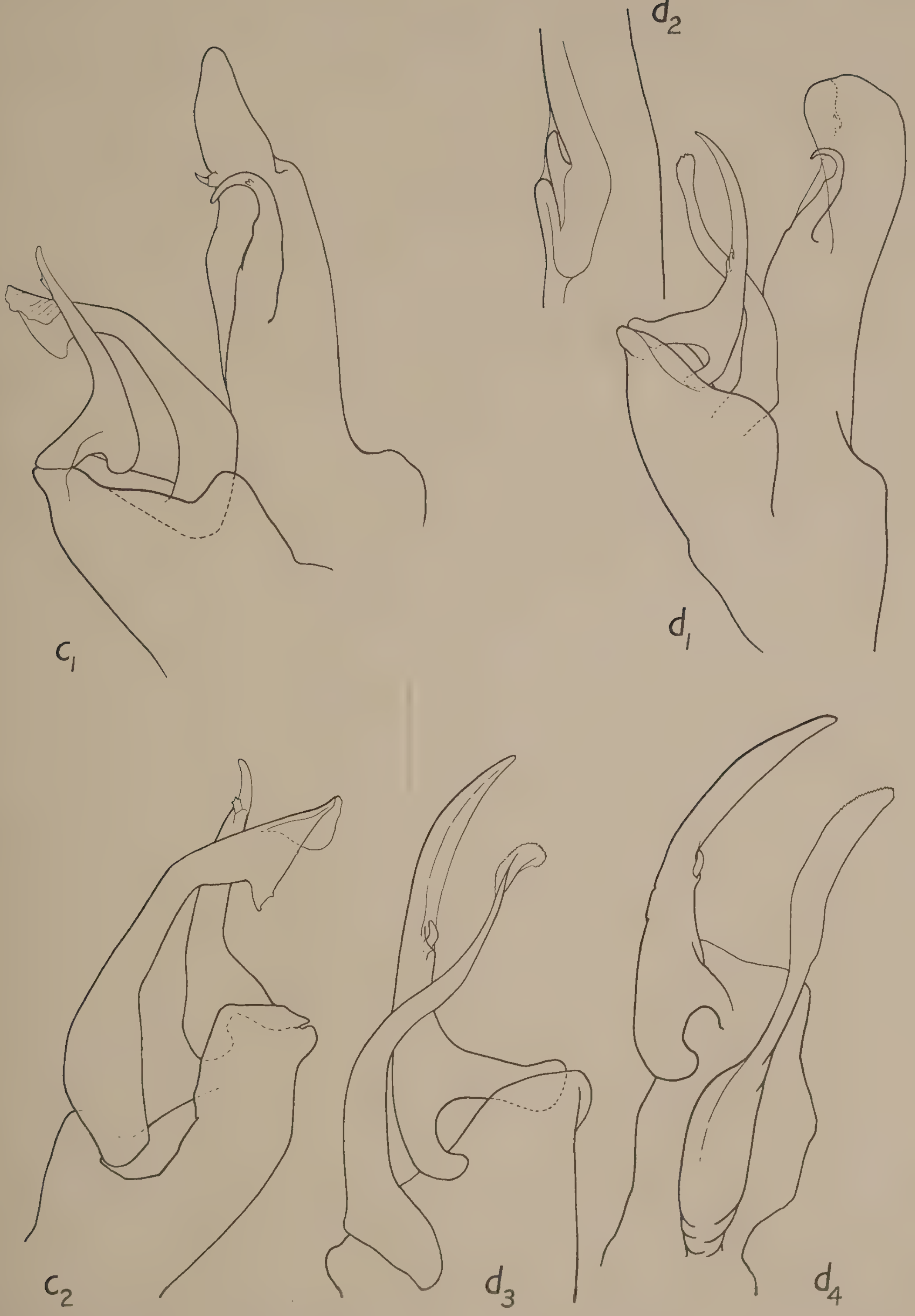

Fig. 28. Male copulatory organs of the left side of the species of group *d* (*cont.*). *c*, *E. longirostris*: 1, inner and median lobes from behind, ×86; 2, terminal and proximal processes from in front, ×110. *d*, *E. triacantha*: 1, inner and median lobes from behind, ×60; 2, finger-like process of terminal process enlarged; 3, terminal and proximal processes from in front, ×80; 4, terminal and proximal processes from the outer side, ×80.

differences, so similar to one another, that there can be no doubt that the three species are closely related.

GROUP *d*

The second natural group, Group *d*, comprises four species described in this report. In addition to possessing spines on the third, fourth and fifth abdominal segments they resemble one another and differ from all others in having, like Group *a*, a characteristic secondary structure on the terminal process of the male copulatory organ. Half-way along it in *E. triacantha*, much nearer the end in the other three, a short blunt strongly chitinized secondary process arises from the inner or the front side;[1] beyond it the process is flattened and less heavily chitinized than before (Fig. 28).

The order in which these species occur from north to south is as follows:

E. hanseni: known only from the tropical zone off the west coast of Africa.
E. spinifera: circumpolar in the sub-tropical zone.
E. longirostris: circumpolar in the sub-Antarctic zone.
E. triacantha: circumpolar in a narrow belt in the colder water of the sub-Antarctic, and throughout the ice-free water of the Antarctic, zones.

In some structural characters *E. hanseni* is nearer to *E. spinifera* than to either of the others, *E. spinifera* stands midway between *E. hanseni* and *E. longirostris*, and the latter midway between *E. spinifera* and *E. triacantha*. It is not easy to see these relationships in all characters, but since they are shown by some, and since those which do not show them do not point to any other order of relationship, I think it reasonable to believe that the resemblances are the more significant, and that they show the true evolutionary relationships of the species.

The shape of the carapace is very similar in all, except that in *E. triacantha* it is not produced anteriorly into post-ocular spines.[2] In *E. hanseni* there is a pair of strong sharp hepatic spines, each arising from a low mound-like projection on the side of the carapace; there are similar but blunter spines in *E. spinifera*; in *E. longirostris* and *E. triacantha* there are no hepatic spines, but the low mound-like projections remain, smaller in the latter than in the former (for these and the other comparisons in this and the next paragraph see Figs. 18, 19, 21 and 23). In *E. hanseni* the lateral denticle of the carapace is set above the lower margin and behind a small angle in it; it is set above a deep incision in the lower edge of the carapace in *E. spinifera* and *E. longirostris*; in *E. triacantha* it is on the lower edge. The gastric area of the carapace is keeled in the mid-dorsal line in all; in *E. spinifera* and *E. longirostris* the keel has a characteristic notch.

The hinder edges of the terga of the third, fourth and fifth abdominal segments are indented mid-laterally in *E. hanseni*; they are deeply incised in *E. spinifera* and *E. longirostris*, more so, in that the third segment has more incisions, in the former than the latter; they are faintly indented mid-laterally in *E. triacantha*.

The characters of the antennular peduncles are shown in the following table (see Figs. 18, 19, 21 and 23).

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[1] It is quite different in appearance from the slender thin-walled finger-like process near the end of the terminal process in the seven species of Group *a*, and from the structure in a similar position in *E. similis*.

[2] Post-ocular spines are not found in any other species of the genus than *E. hanseni*, *E. spinifera* and *E. longirostris*.

Characters of the first and second segments of the antennular peduncles	*E. hanseni*	*E. spinifera*	*E. longirostris*	*E. triacantha*
Lobe of first segment:				
Narrower than second segment, bifid	×	—	—	×
Narrower than second segment, 2 or 3 pointed	—	—	×	—
Wider than second segment, 4 to 6 or more points	—	×	—	—
Second segment, dorsal surface:				
Distal end of inner edge:				
With a high keel, pointed distally	×	—	—	—
With a low keel	—	×	—	—
With a very low keel	—	—	×	—
No keel present	—	—	—	×
Distal margin:				
A thick blunt protuberance from the outer corner	×	—	—	—
A strong tooth-like projection, divided into 2 points arising from the middle	—	×	—	—
A strong spine arising from the middle	—	—	×	—
A smaller spine arising from the middle	—	—	—	×

Figures of the copulatory organs of the four species have been grouped together in Fig. 28 so that they may easily be compared. Those of *E. spinifera* and *E. longirostris* are very similar indeed, although there are constant and unmistakable differences (p. 230). There is not so close a similarity between those of *E. hanseni* and *E. spinifera*, but they are of the same plan: the terminal processes are alike, and although the ends of the proximal processes are quite different in outline they are both membranous expansions in an approximately vertical plane. At least it can be said that the copulatory organ of *E. hanseni* is not more similar to that of *E. longirostris* than to that of *E. spinifera*; it is certainly nearer to *E. spinifera* than to *E. triacantha*. That of *E. triacantha* is more unlike the other three than any other—it appears as dissimilar to those of *E. longirostris* and *E. spinifera* as to that of *E. hanseni*.

There is an increase in the size of the species as one passes from warm to colder water, as the following table shows:

Species	Length of largest ♂ mm.	Length of largest ♀ mm.
E. hanseni	25	27
E. spinifera	29	29
E. longirostris	33	34
E. triacantha	41	40

The larval stages of *E. hanseni* are not known. In *E. spinifera* and *E. longirostris* the Calyptopis and earliest Furcilia stages have the edges of the carapace denticulate, more completely so in the latter than the former; they have the same sequence of Furcilia stages. *E. triacantha* has a different sequence of Furcilia stages; the edge of the carapace is not denticulate in the Calyptopis or Furcilia.

To sum up: Each of the four species of Group *d* occupies one of four successive zones of water from north to south. I take this to be such strong evidence of their evolutionary relationships that I attach much more weight to the few characters which appear to confirm it than to those which do not, since I see among the latter none which suggests another order of relationship.

The most striking fact brought out in the comparison of the four species above is the close resemblance between *E. spinifera* and *E. longirostris*, the middle two of the series.

One of the strongest differences between them is that *E. spinifera* has hepatic spines while *E. longirostris* has not. It is surely significant that *E. hanseni* should have hepatic spines like *E. spinifera* and that *E. triacantha* should, like *E. longirostris*, have none, but that both should have a mound-like projection on the carapace similar to that from which the spines arise in the other two. It is significant too that it is an end member of the series that differs most from all the others—that it is *E. triacantha* that has no post-ocular spines and a copulatory organ most unlike those of the other three. In the character of the structures on the second segment of the antennular peduncle there is an appearance of a progression or trend which corresponds with the order of occurrence of the species.

THE SOUTHERN GROUP

My second natural group, which I shall call the Southern Group, comprises *E. lucens*, *E. vallentini*, *E. frigida*, *E. superba* and *E. crystallorophias* and has not before been recognized as such; *E. vallentini* comes from Hansen's Group *c*, the other four from Group *b*. They share no obvious external characters, such as the abdominal spines of Group *d*, to make them look like related species. I find the relationship to be shown by the structure of the male copulatory organs, especially by that of the proximal process.

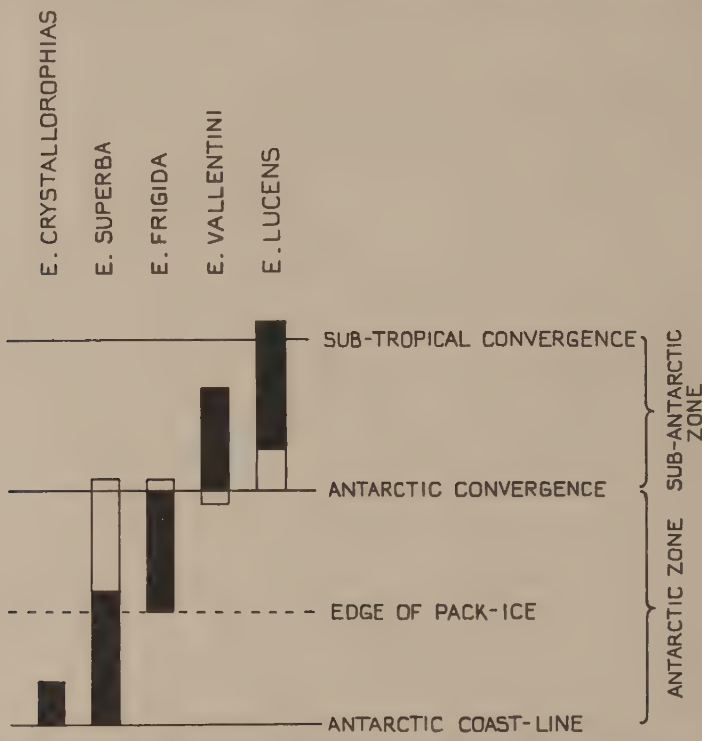


Fig. 29. Diagram showing the distribution of the species of the southern group of *Euphausia* in the surface zones of water in the southern oceans; the blacked in portion of each column shows the normal range of that species, the entire column the possible range.

All are circumpolar in range, and the order of their normal occurrence from north to south is as follows:

E. lucens: all but the coldest water of the sub-Antarctic Zone.
E. vallentini: all but the warmest water of the sub-Antarctic Zone.
E. frigida: the ice-free water of the Antarctic Zone.
E. superba: under the pack-ice and along its edge, and in the colder water of the Antarctic Zone.
E. crystallorophias: along the coasts of the Antarctic Continent.

The normal and the possible north-to-south range of each species is shown diagrammatically in Fig. 29.

Figures of the copulatory organs of the five species have been grouped together in Fig. 30 so that they may easily be compared. Those of *E. lucens*, *E. vallentini* and *E. frigida* are, despite constant and unmistakable differences, so similar that it will be best to consider them first (Fig. 30 *a*, *b*, *c*).

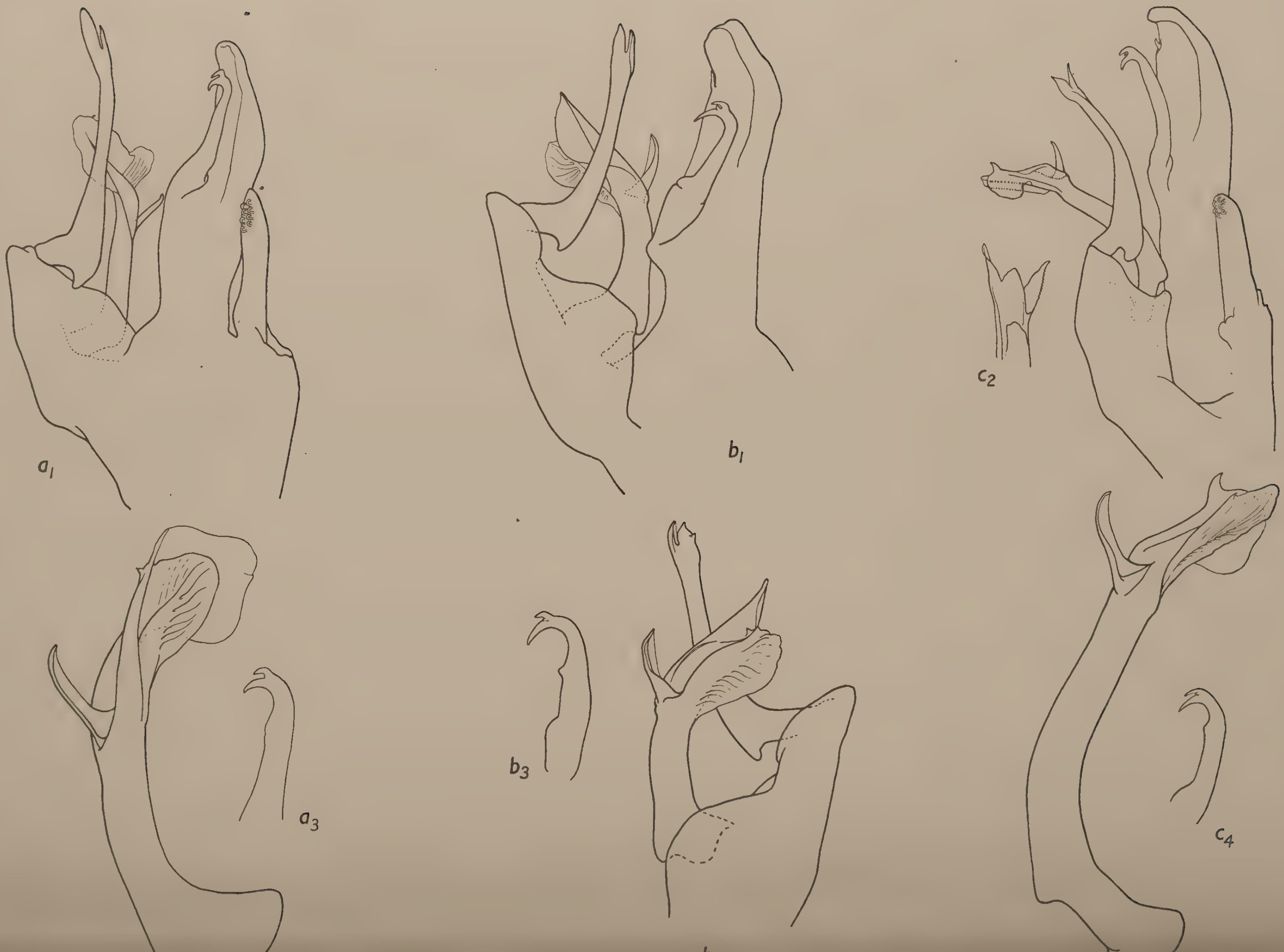
The terminal processes of all three are alike in general shape. The distal end is cleft into an inner and an outer branch. In *E. lucens* the inner branch is much the stronger and longer; in *E. vallentini* it is the stronger, and it may be a little longer than, or of the same length as, the outer. In *E. frigida* both branches are flattened, not rounded as in the other two species; the innermost is the bigger, and it is divided distally into two unequal lobes, the front one longer and larger than the other; the hinder edge of the outer lobe is finely serrate.

The proximal processes of the three species are very alike. There is an angle or heel on the outer side near the base. The distal part is bent inwards, and from the outer side of the bend, and a little to the front, there springs a strong blade-like secondary process which is curved gently inwards. On the part of the proximal process beyond it there are two thin membranous expansions, a larger one behind, a smaller one with a striated appearance in front. In *E. lucens* the front expansion is much smaller than the hinder one and does not reach so far forward (i.e. distally); in *E. vallentini* it is more nearly equal in size to, and reaches nearly as far forward as, the hinder; in *E. frigida* it reaches a little farther forward. Between the ends of the membranous expansions there is in *E. frigida* a strong curved protuberance; a careful search shows its counterpart, a much smaller tooth-like projection which is not curved, in *E. vallentini* and *E. lucens*.

The lateral processes of the three species are very similar. There is a long nearly straight shaft, the end of which is bent strongly and sharply inwards; on the outside of the bend there is a strong tooth. In *E. vallentini* and *E. frigida* there is a tiny projection in the axil of the tooth on the hinder side.

There can be no doubt that *E. lucens*, *E. vallentini*, and *E. frigida*, having such very similar male copulatory organs, are closely related species. Although the organs of *E. superba* and *E. crystallorophias* (Fig. 30 *d*, *e*) are at first sight very different from theirs, and from one another, I find that they share with them characters not possessed by any other species of the genus. The relationship is shown by the proximal process only in *E. superba*, by the proximal process most clearly in *E. crystallorophias*.

The base of the proximal process of *E. superba* has no heel on the outer side as in *E. lucens*, etc., but it is curved inwards. The distal part of the process is bent inwards and it carries two membranous lobes, a distal one lying for the most part on the hinder side of the process and one on the front side placed farther back. The latter is striated in the same way as the front lobe in *E. lucens*, *E. vallentini* and *E. frigida*. There is no strong blade-like secondary process on the bend, but in the majority of males, though not in all (p. 218), there is a spine of variable size bent forwards over the middle of the foremost membranous lobe. I regard it as homologous with the larger secondary process in *E. lucens*, *E. vallentini* and *E. frigida*. It has not been described before.


a1
b1
c2
c1
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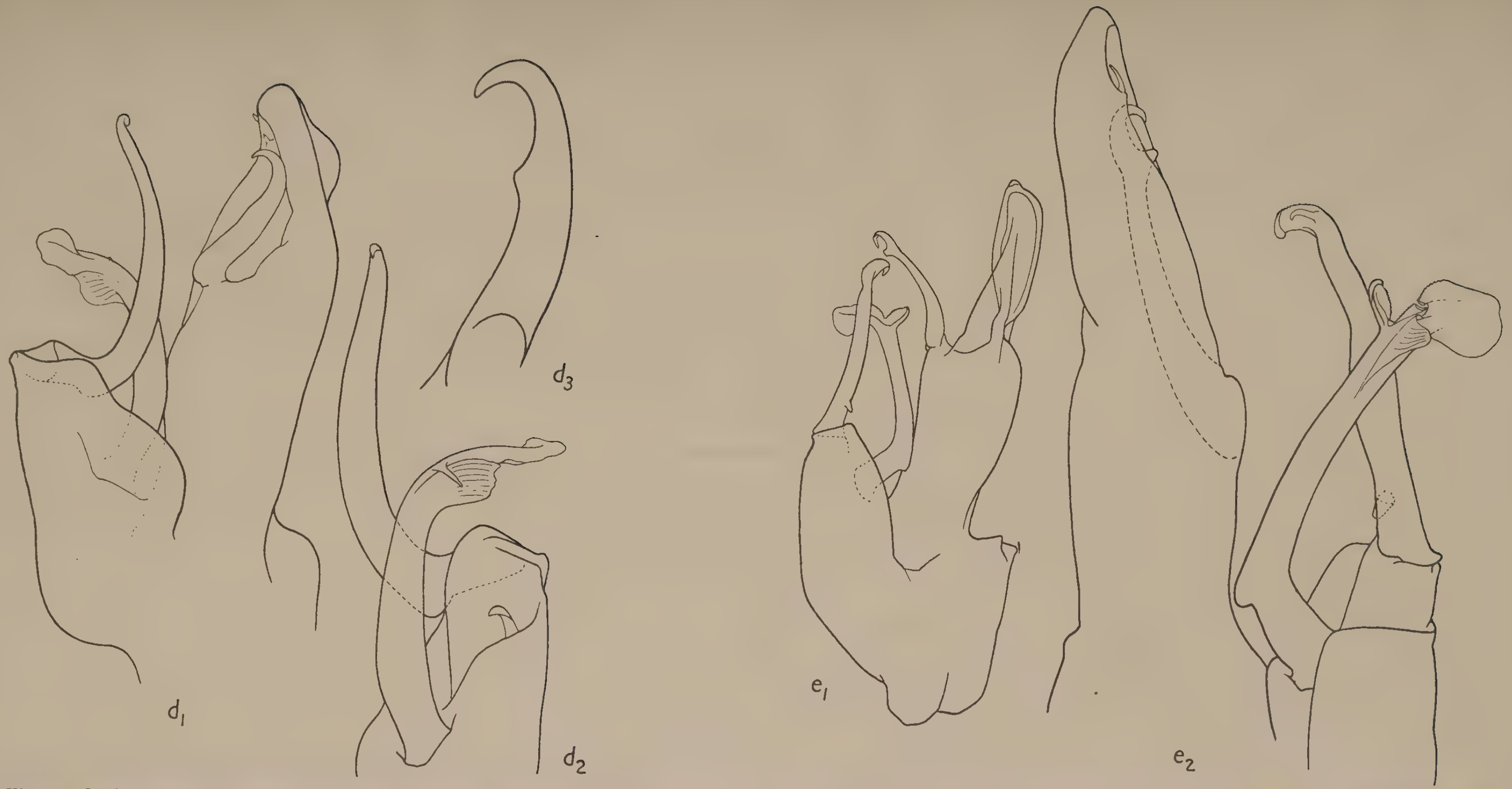

Fig. 30. Male copulatory organs of the left side of the species of the Southern group. *a*, *E. lucens*: 1, inner and median lobes from behind, × 82; 2, proximal process from in front, × 158; 3, end of a lateral process (see note below) from behind, × 120. *b*, *E. valentini*: 1, inner and median lobes from behind, × 75; 2, terminal and proximal processes from in front, × 75; 3, a lateral process (see note below) from behind, × 82. *c*, *E. frigida*: 1, inner and median lobes from behind, × 75; 2, detail of end of terminal process from behind; 3, proximal process from in front, × 165; 4, a lateral process (see note below) from behind, × 82. *d*, *E. superba*: 1, inner and median lobes from behind, × 45; 2, terminal and proximal processes from in front, × 52; 3, a lateral process (see note below) from behind, × 82. *e*, *E. crystallorophias*: 1, inner and median lobes from behind, × 60; 2, from in front, × 150.

Note. The separate figures of lateral processes of *E. lucens*, *E. vallentini*, *E. frigida* and *E. superba* show how in each of these species it may approach the shape characteristic of that of *E. crystallorophias*.

The proximal process of *E. crystallorophias* has a strong heel-like angle on the outer side near the base. Its distal part is bent inwards. From near the bend there springs a strong secondary process very similar to that of *E. lucens*, *E. vallentini* and *E. frigida*, more heavily chitinized along its outer edge than its inner, which is membranous, convex and serrate. There are, as in the other four species, two membranous lobes on the end of the proximal process, a larger distal and hinder one, a very small striated one on the front side which has not been described before. The latter lies, as in *E. superba*, under the point from which the secondary process arises, not in front of it (i.e. not more distally than it) as in *E. lucens*, *E. vallentini* and *E. frigida*.

The terminal process of *E. superba* is not similar to that of *E. lucens* and the others; it does not have the same kind of foot-like base, and its distal end is curved and pointed, not cleft in two. The lateral process has no secondary tooth.

The terminal process of *E. crystallorophias* has a narrow base, but there is a sharp projection near its outer side which may be homologous with the well-defined heel of the wide foot-like base of *E. lucens*, *E. vallentini* and *E. frigida*. Its distal end is divided into two very unequal parts, of which the hinder and outermost is the larger; its inner edge is, like the hinder edge of the outer lobe in *E. frigida* to which I suppose it to correspond, finely serrate. If these parts are indeed homologous, it is very interesting to find this closer relation between the neritic species of the Antarctic coasts and *E. frigida* from the Antarctic Zone than can be found between it and *E. vallentini* and *E. lucens* from the distant sub-Antarctic.

The lateral process of *E. crystallorophias*, like that of *E. superba*, carries no secondary tooth. It is longer in proportion to the length of the terminal and proximal processes than in any of the other species, and it is differently shaped. It is perhaps significant that the cargo-hook shape of its end is one I have seen approached in one or more of the comparatively few petasmas of *E. lucens*, *E. vallentini*, *E. frigida* and *E. superba* that I have examined (Fig. 30 *a* 3, *b* 3, *c* 4, *d* 3).

It is because I find that the proximal processes of *E. superba* and *E. crystallorophias* are, despite differences in general appearance, made up part for part like those of *E. lucens*, *E. vallentini* and *E. frigida*, which are very similar to one another, that I regard the five species as forming a natural group. In no other species of the genus does the proximal process carry a similar secondary process, or have at its distal end two membranous expansions, a hinder one larger and more distal, a front one with characteristic striations. The distribution of the members of the group in contiguous or overlapping habitats throughout sub-Antarctic and Antarctic waters appears to me to be at once a confirmation and an explanation of their relationship; the only other species occurring in these waters are *E. similis* which is not related to them, in the sub-Antarctic, and *E. longirostris* and *E. triacantha* which are members of another clearly defined group. In other words I regard the present group as an offshoot of the genus *Euphausia* from lower latitudes to the colder waters of the south.

I have looked within the group for evidence of a constant trend, a progressive change in structure, showing that the species form a series corresponding with the order in which they occur from north to south; showing, that is, that *E. vallentini* stands between *E. lucens* and *E. frigida*, and *E. frigida* between *E. vallentini* and *E. superba*, and so on. Their structure does not show so ideal a series, but it does I think show that the conception is a true one.

In the first place the copulatory organs have shown the three most northerly species to be closely related. Those of *E. superba* and *E. crystallorophias*, although very different from one another, have two things in common which may show a closer relationship between them than they have with the other three: the foremost membranous lobe on the proximal process is set far back beneath the secondary process, not more distally than it as in *E. lucens*, *E. vallentini* and *E. frigida*; the lateral process has no secondary tooth. The two species have other similarities, which are at the same time differences from *E. lucens*, *E. vallentini* and *E. frigida*: they are the only ones of the group in which the carapace has a cervical groove and is keeled anteriorly in the mid-dorsal line, and in which it is produced into a well-marked projection behind each eye; the rostral projection is stronger in them than in the other three (Fig. 31). Although the first segment of the antennular peduncle has an enormous lobe in *E. superba* and none in *E. crystallorophias*, it may have in the former, and it always has in the latter, a spine on the outer distal corner such as is not found in adult *E. lucens*, *E. vallentini* or *E. frigida* (Fig. 32).[1] If these are evidences of affinity then the group of five species falls into two divisions corresponding with the order of their occurrence from north to south—a northerly and a southerly division.

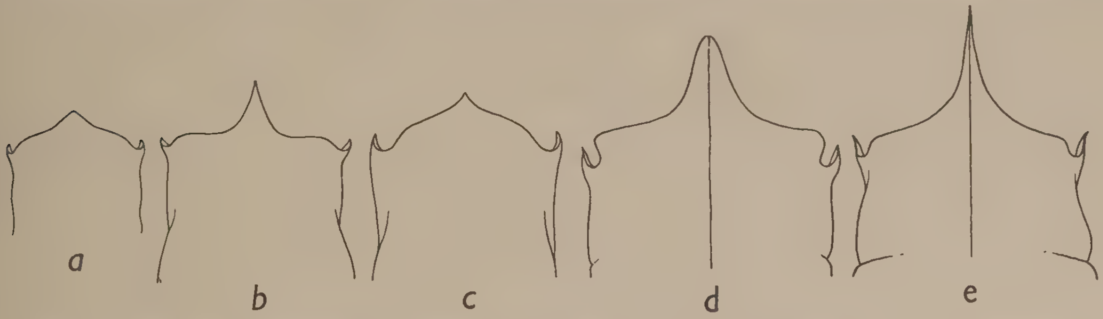

Fig. 31. Front part of carapace of the species of the southern group: *a*, *E. lucens*, × 12; *b*, *E. vallentini*, × 12; *c*, *E. frigida*, × 12; *d*, *E. superba*, × 10; *e*, *E. crystallorophias*, × 12.

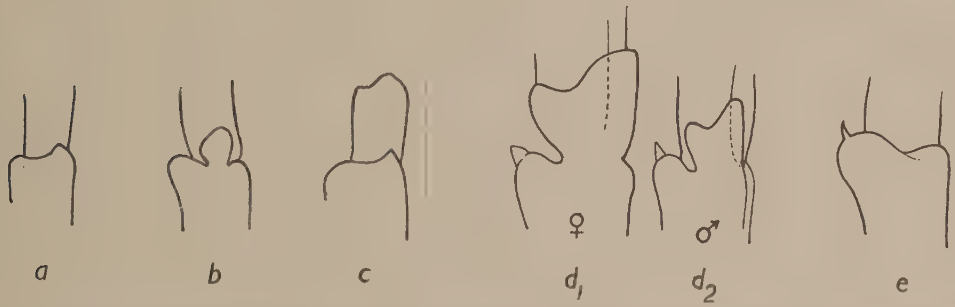

Fig. 32. Ends of the basal segments of the left antennular peduncles of the species of the southern group showing lappets and spines, from above. *a*, *E. lucens*; *b*, *E. vallentini*; *c*, *E. frigida*; *d*, *E. superba*; *e*, *E. crystallorophias*. *a*, × 18; *b*, *c* and *e*, × 12; *d* 1, × 10; *d* 2, × 11.

The copulatory organs of the northerly species have some features which suggest that their relationship is in the order *E. lucens*, *E. vallentini*, *E. frigida*—which is that of their occurrence from north to south. *E. vallentini*, the middle member, shares with each of the end members a character not possessed by the other: the two parts into which the end of its terminal process are cleft are blunt and rounded as in *E. lucens*, not flattened with one part lobed and the other serrated as in *E. frigida*; but, like *E. frigida* and unlike *E. lucens*, its lateral process has a tiny projection near the axil of the distal tooth. It stands midway between them in the proportional lengths of the terminal and proximal processes: in *E. lucens* the terminal is longer than the proximal, in *E. vallentini* the proximal is longer than the terminal, and in *E. frigida* it is proportionately longer still. If the species form a true series one would expect that if any one of them had a structure, possessed by all three, more strongly developed than the other two it would be an end member. *E. frigida* has the distal tooth between the membranous lobes of the proximal process more strongly developed than in *E. vallentini* and *E. lucens*; I have not found a secondary process on the median lobe in *E. lucens* as in the other two.

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[1] Or in any other species in the genus.

E. vallentini has, however, other characters sharply distinguishing it from *E. lucens* and *E. frigida*, which make it appear unlike a species standing midway between them. It is larger than either of them. It has a dorsal process on the posterior margin of the third abdominal segment which caused Hansen to include it in his Group *c*. The front end of its carapace and the rostrum are differently shaped to those of *E. lucens* and *E. frigida* which are similar to one another (Fig. 31). *E. lucens* has a moderate or small, *E. frigida* a very small triangular lobe from the end of the first segment of the antennular peduncle; *E. vallentini* has a very characteristic lobe, large and rounded (Fig. 32). It has a high rounded dorsal keel on the third segment of the peduncle, whereas *E. lucens* and *E. frigida* have lower keels with straight upper margins (Fig. 33).

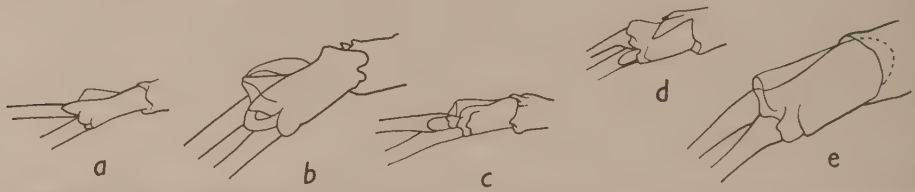
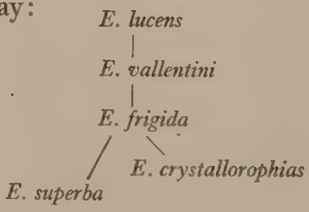


Fig. 33. Third segments of the left antennular peduncles of the species of the southern group showing the shapes of the dorsal keels, etc., from the outside. *a*, *E. lucens*; *b*, *E. vallentini*; *c*, *E. frigida*; *d*, *E. superba* (after Hansen); *e*, *E. crystallorophias*. Not on the same scale.

I am inclined to attach more importance to the structure of the male copulatory organs which places *E. vallentini* between *E. lucens* and *E. frigida*, as it occurs in space, than to size and the other structures—the abdominal spine, the sharp rostrum and the antennular lappet—which make it appear more distant from *E. lucens* and *E. frigida* than they are from one another.

Of these three species *E. frigida* alone occurs in the Antarctic like *E. superba* and *E. crystallorophias*, its range overlapping that of the former but not that of the latter. It would be difficult to show that either of them is more closely related to it than the other. On the whole *E. crystallorophias* shows the fewest differences. The terminal process of its copulatory organ is divided distally into two parts, and the inner edge of the outer is serrated like the hinder edge of the outer, to which I think it corresponds, in *E. frigida*. The proximal process is more like that of *E. frigida* in general shape and in the possession of a strong secondary process than is that of *E. superba*. The antennular peduncle of *E. crystallorophias*, with no lobes on the first and second segments, is less unlike that of *E. frigida* than *E. superba*'s is. But there are big differences too, and no good reason that I can see for regarding *E. crystallorophias* as intermediate between *E. frigida* and *E. superba*.

To sum up, I think the structural evidence may be sufficient to represent the colonization of southern waters by this well-marked group or branch of the genus *Euphausia* in the following diagrammatic way:



THE LATER LARVAL DEVELOPMENT OF FIVE SPECIES

LARVAL DEVELOPMENT

Fraser (1936) has just published in this volume an account of his examination of the larval stages of *Euphausia superba*, more detailed and based upon far larger numbers of specimens than any previous account of the development of a euphausiid. He discards the division of the later larval stages of the Euphausiidae into Furcilia and Cyrtopia. The division was based upon the change in form and function of the antenna from a swimming to a non-swimming organ: in the Furcilia the limb was directed outwards, and the endopod and exopod were similar to one another in size and shape; in the Cyrtopia the endopod was segmented and the exopod scale-like, the whole pointing forwards. Fraser points out that this change in form is not of the same magnitude as those which distinguish other stages (for example, the Calyptopis and Furcilia), and he shows that it is one of several changes of, seemingly, as great a magnitude and significance which take place at about the same time, but not necessarily at exactly the same time. He has called all those stages, which were before called Furcilia and Cyrtopia, Furcilia stages, and in this I follow him.

Brook and Hoyle (1888, p. 419) recognized, by the comparative development of the pleopods, eleven Furcilia stages—using the term in its old sense—in one species, though Lebour (1925, pp. 811–12) appears to imply that that one species might have been a mixture of two (*Thysanoessa*) species. Lebour in her *General Survey of Larval Euphausiids, etc.* (1926 *b*, pp. 523–4) gave (i) a list of the kinds of euphausiid Furcilia, fourteen in number, which had been found at that time, and (ii) a list of the species of which larvae had been found, showing, where those larvae included the Furcilia, what Furcilia stages they were. The largest number of stages out of the fourteen "possible" ones to be found in one species was eleven—in both *Nyctiphanes couchii* and *Meganyctiphanes norvegica*. She stated (p. 525) that "the evidence is in favour of a certain order of development of the pleopods" (i.e. a certain succession of Furcilia stages) "in the various genera"; and that these "distinctive stages" (of a genus) "nearly always seem to occur as though certain stages were dominant". "There is distinct evidence of the jumping of stages in some species." In a later paper she gives examples of dominant Furcilia stages in two species, *Nematoscelis microps* and *Euphausia krohnii* (Lebour, 1926 *c*, pp. 766, 770), and a description of what is undoubtedly the succession of dominant stages (though she does not call them that) in a third species, *Thysanopoda aequalis* (p. 768). Macdonald (1927), the first worker to publish a paper with quantitative results on the larval stages of a euphausiid, showed that of 302 specimens, including eleven Furcilia stages, of *Meganyctiphanes norvegica* nearly 20 per cent were of one stage and over 26 per cent of another, higher, stage; the remaining 54 per cent being made up of the totals of the other nine Furcilia stages. The two stages which occurred in far greater numbers than any of the others he described as "tending to be dominant".

Rustad's records (1934, pp. 15, 28–30, 41) of the analyses of seventy-five Furcilia of *Euphausia frigida*, and of 708 of *Thysanoessa* (*macrura* and *vicina*), show that in both only three stages occurred; the stages in *Euphausia frigida* were different from those in *Thysanoessa*.

Fraser (1936, p. 55) shows that in each of the examples of a succession of "dominant" Furcilia stages given above the relationship of a lower stage of the succession to the next higher is the same: the higher rises from the lower by the non-setose pleopods of the lower becoming setose,[1] and (if the number of pairs of pleopods of the lower is not already the full number, five) by the addition posteriorly of a pair, or of pairs, of non-setose pleopods. (This is illustrated diagrammatically for my own species in Fig. 34.) He examined enormous numbers (about 3000) of Furcilia (still using the term in its older, more restricted sense) of *Euphausia superba*, and although there were among them fourteen different stages,[2] two groups, each of two successive stages, occurred in far greater numbers than any of the others; these were in other words the dominant stages, and the relationship between them was that given in the previous sentence.

It appears, then, that in euphausiids in which the Furcilia development is best known a few only of the stages that are found within each species occur numerously, and they have an obvious relationship to one another as the members of a series: they are successive instars; in other words the majority of the individuals of a species follow, as Furcilia larvae, the same course in development—and a shorter course than was previously supposed. The numerously occurring stages have been known hitherto, where they have been recognized, as dominant stages: Fraser suggests that in each species they "should be regarded as the actual stages of that part of the developmental history", and the other stages as variants.

The earlier workers had not recognized among the Cyrtopia any dominant stages such as they saw in the Furcilia, but Fraser found that in *E. superba* "in the succession of moults which follow on the larvae having five setose pairs of pleopods...the ecdyses generally coincide with a reduction in the number of terminal spines on the telson from 7 to 5, 5 to 3 and 3 to 1, but that...by no means all the larvae conform to this scheme". Since most of them do he regards those with five, three and one terminal spines on the telson in the same way as the "dominant" Furcilia stages, that is, as actual stages of the developmental history, and those with other numbers as abnormalities. He calls them all, as I have said, Furcilia and not Cyrtopia.

In these ways he gives a new use to the term "Furcilia stage":

Lebour's Furcilia stage is any one of the various Furcilia (in the old sense, i.e. with unsegmented antennal endopod) which occur: the form with no pleopods and each one of the forms represented by the several combinations of pairs of non-setose, of setose and non-setose, and of setose pleopods, is a Furcilia stage. There may be as many as fourteen (*E. superba*, Fraser, 1936) in one species.

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[1] Fraser examined 262 *Euphausia superba* Furcilia having non-setose pleopods and in all of them those pleopods "had within the integument the rudiments of setae", so that when they moulted they must become setose. Macdonald (1927, p. 789), however, saw *Meganyctiphanes norvegica* Furcilia with non-setose pleopods moult and some of the pleopods remain non-setose.

[2] Although this number of stages agrees with Lebour's number of 14 "possible (or known) stages" they are not identical: Fraser did not find three of the stages given by Lebour but he found three stages that were not known before. The number of known stages thus becomes seventeen.

Fraser's Furcilia stage. Each of the earlier of Fraser's Furcilia stages is a group of Lebour's stages centred around, and made up for the most part (in terms of the numbers occurring) of one[1] of her dominant stages; there are as many of Fraser's earlier Furcilia stages in a species as there would be of Lebour's dominant stages. His later stages, those among the forms that were previously called Cyrtopia, are recognized by the number of terminal spines on the telson; those with five, three and one spines form, respectively, successive stages.

The results of my work on the larval stages of five species of *Euphausia*, only one of which is mentioned above, confirm Fraser's view of euphausiid development. In the pages that follow the term Furcilia stage has Fraser's meaning (or something very near it), and I use Furcilia, as he does, to include both the Furcilia and the Cyrtopia of earlier writers.

I have examined large numbers of Furcilia of *E. frigida*, *E. vallentini* and *E. triacantha*, smaller numbers of those of *E. longirostris* and *E. spinifera*. In Table I the forms which occurred in these species and the numbers of each are shown. The numbers of *E. longirostris* include those recorded by Sars and Tattersall (one and twenty respectively, see p. 285); the numbers of *E. spinifera* include six that I have examined from the Deutsche Tiefsee-Expedition material (see p. 294). The forms which, in the various species, are Furcilia stages are distinguished by having the numbers in which they occurred printed in heavy type.

It is convenient to consider the two groups of forms shown in Table I separately:

Those recognized by the character and number of the pleopods. The table makes it clear that the course of early Furcilia development in *E. frigida*, *E. vallentini* and *E. triacantha* is more fixed than it is known to be in any other euphausian; almost all the individuals of a fairly large collection of each species belong to one of three Furcilia stages which are the same in each species; very few other forms occur (two, one and two respectively of the three species) and specimens of them are rare. In Lebour's terms it might be said that the dominant stages are almost the only ones.

The numbers of *E. longirostris* and *E. spinifera* are few, but it is significant that those few belong, with the exception of one *E. spinifera*, to one of four Furcilia stages which are similar in both species. I believe that if large numbers of the early Furcilia of *E. longirostris* and *E. spinifera* were seen, most of them would be found to belong to those four stages.

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[1] This definition does not strictly cover *E. superba*: its dominant earlier Furcilia stages, of which there are two, are each made up of *two* Furcilia stages in Lebour's sense; the first is of individuals having four or five pairs of non-setose pleopods and it follows that the second is of individuals having four pairs of setose and one pair of non-setose, or five pairs of setose pleopods. In the examples of Euphausiid development that Fraser quotes from earlier writings, and in the five species that I describe here, each dominant stage is one Furcilia form, one of Lebour's Furcilia stages.

Table I. *Showing the Furcilia forms which were found, and the numbers of each, in five species of* Euphausia

Furcilia forms	*E. frigida**	*E. vallentini*	*E. triacantha*	*E. longirostris*	*E. spinifera*
Forms recognized by the character and number of the pleopods. Antennal endopod unsegmented:					
1 pair of non-setose pleopods	—	—	—	18	11
3 pairs of non-setose pleopods	1	—	—	—	—
4 pairs of non-setose pleopods	123	62	310	—	—
5 pairs of non-setose pleopods	1	—	5	—	—
1 pair of setose, 2 pairs of non-setose pleopods	—	—	—	—	1
1 pair of setose, 3 pairs of non-setose pleopods	—	—	—	7	2
3 pairs of setose, 2 pairs of non-setose pleopods	—	3	1	—	—
4 pairs of setose, 1 pair of non-setose pleopods	194	47	343	6	5
5 pairs of setose pleopods	220	135	247	14	8
†With 7 terminal spines on telson	219	47	All	All	All
†With 6 terminal spines on telson	—	7	—	—	—
†With 5 terminal spines on telson	1	57	—	—	—
Forms recognized by the number of terminal spines on the telson. Antennal endopod segmented:					
8 terminal spines on the telson‡	—	—	(2)	—	—
7 terminal spines on the telson	4	—	136	—	—
6 terminal spines on the telson	(2)	—	(11)	(1)	—
5 terminal spines on the telson	117	20	71	6	4
4 terminal spines on the telson	(4)	(12)	(1)	(3)	—
3 terminal spines on the telson	44	93	11	6	6
2 terminal spines on the telson	(10)	(15)	(3)	—	—
1 terminal spine on the telson	98	111	16	1	9

In the second group the number of those individuals with even numbers of terminal spines are enclosed in brackets to indicate that they are regarded as abnormalities and not as variants of equal value to those in the first group having unusual numbers of pleopods.

* Compare with Rustad's results quoted above; his three dominant forms are the same as the first three of my Furcilia stages.

† The numbers of *E. vallentini* are of 111 specimens in which the telsons were complete.

‡ Eight terminal spines have not previously been recorded, so far as I am aware, for any larval euphausiid.

It is important to notice that although the succession of stages is not the same in the two groups of species, a higher stage of either series arises from the one below it by the non-setose pleopods of the latter becoming setose, and, if the number of pleopods is not already five, by the addition of a pair or of pairs of non-setose pleopods. This is shown diagrammatically in Fig. 34. The five squares of each rectangle represent the first to fifth abdominal segments of an individual, the first on the left, the fifth on the right; a simple line represents a non-setose pleopod, a line forked at the end a setose pleopod.

These I regard as the earlier Furcilia stages of the two groups of species because they are, certainly in the first group and almost certainly I think in the second, the instars by which development proceeds in the vast majority of the individuals. They are described in the pages that follow as Furcilia I–III of the first group, Furcilia I–IV of the second.

Those recognized by the number of terminal spines on the telson. In the five species, as in *E. superba*, the path of development is usually one coincident with the reduction of the number of terminal spines on the telson from seven to five, five to three and three to one (Table I). Even numbers of terminal spines are abnormalities (Fraser, 1936, p. 51), and individuals having them are not regarded as variants of the same value as those of the earlier group with unusual numbers of pleopods. In *E. triacantha* only does the first of these later stages have the original number of seven terminal spines; in the other four species it has been reduced to five.[1]

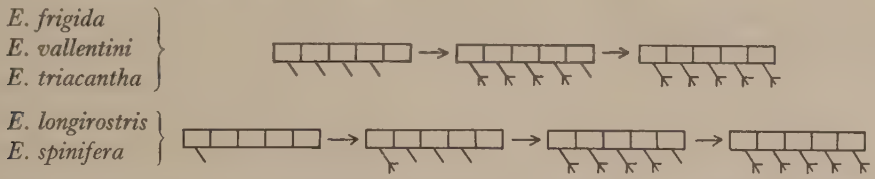

Fig. 34. Diagram showing the paths of early Furcilia development in five species of *Euphausia*. Explanation given in the text.

The last of the Furcilia stages to be recognized by the number and character of the pleopods have, in all except *E. vallentini*, seven terminal spines on the telson (except for one *E. frigida*); in *E. vallentini* there are either seven or five or, exceptionally, six spines. A number of this stage with seven spines and a number with five were examined to see how many spines would be present in the succeeding stage. It could be seen in very few of them. Of ten having seven terminal spines one was going to have six spines after moulting, six five spines, one four spines, and two three spines;[2] of twenty with five spines 1 appeared as though it were going to have five spines again after moulting, 17 were going to have three spines, and 2 two spines. It seems then that the majority of those with seven terminal spines would have, after moulting, five spines, the majority of those with five, three. It is, no doubt, for this reason that the number of individuals (20)

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[1] In regarding the single Furcilia forms as stages I differ a little from Fraser. For example: His Furcilia I of *E. superba* is made up of forms with no pleopods, or with two, three, four or five pairs of non-setose pleopods; of these he saw in all the following numbers:

With no pleopods	8
With two pairs of non-setose pleopods	4
With three pairs of non-setose pleopods	16
With four pairs of non-setose pleopods	110
With five pairs of non-setose pleopods	942

The sum of the three infrequently occurring forms (28) is 2·5 per cent of the total of all five forms (1080).

My Furcilia I of *E. frigida*, *E. vallentini* and *E. triacantha* is of individuals having four pairs of non-setose pleopods. Of *E. vallentini* I saw sixty-two with four pairs of non-setose pleopods and none with any other number. Of *E. frigida* there were 123 with four, one with three, and one with five pairs of non-setose pleopods; of *E. triacantha* 310 with four, five with five, pairs of non-setose pleopods. It seemed to me better to record the infrequent forms as exceptions or variants, than to widen the definition of the stage so as to include them. In both *E. frigida* and *E. triacantha* the percentage of the variants is 1·6 per cent; it is less than in *E. superba*, but in both based upon smaller numbers. In *E. vallentini* there were no variants.

[2] Lebour (1926 *c*, p. 768) found in the "sixth furcilia" of *Nematoscelis microps* "specimens with seven spines giving rise to three, which show under the skin".

of the stage distinguished by having five terminal spines on the telson is small compared with those of the stages before and after it. The individuals of *E. vallentini* with five terminal spines on the telson do not as in the other species make a natural group: some of them have an unaltered antenna and are in other ways nearest to, or indistinguishable from, those with five pairs of setose pleopods and seven terminal spines; the remainder have the antennal endopod segmented, the exopod scale-like, are bigger, and have the thoracic limbs and gills more developed. For this reason the Furcilia larvae of *E. vallentini* with five terminal spines on the telson are divided between two stages.

In the group of stages recognized by the number and character of the pleopods *E. longirostris* and *E. spinifera* have one stage more than *E. frigida*, *E. vallentini* and *E. triacantha*; in the group recognized by the number of terminal spines on the telson *E. triacantha* has one stage more than any of the other species. This is shown in Table II.

Table II. *Showing the characters of the Furcilia stages in the five species of* Euphausia *and the numbers by which they are known*

Furcilia stages	*E. frigida*	*E. vallentini*	*E. triacantha*	*E. longirostris*	*E. spinifera*
Antennal endopod unsegmented:					
1 pair of non-setose pleopods	—	—	—	I	I
4 pairs of non-setose pleopods	I	I	I	—	—
1 pair of setose, 3 pairs of non-setose pleopods	—	—	—	II	II
4 pairs of setose, 1 pair of non-setose pleopods	II	II	II	III	III
5 pairs of setose pleopods	III	III	III	IV	IV
Antennal endopod segmented:					
7 terminal spines on the telson	—	—	IV	—	—
5 terminal spines on the telson	IV	IV	V	V	V
3 terminal spines on the telson	V	V	VI	VI	VI
1 terminal spine on the telson	VI	VI	VII	VII	VII

The table shows that a given stage of one species is not necessarily the same as the same stage of another species: stage I of *E. frigida* has four pairs, stage I of *E. longirostris* one pair, of non-setose pleopods. The same set of characters may in two species be diagnostic of two different stages: a Furcilia with four pairs of setose and one pair of non-setose pleopods belongs if it is *E. frigida* to stage II, if *E. spinifera* to stage III; a Furcilia with three terminal spines on the telson belongs if it is *E. vallentini* to stage V, if *E. triacantha* to stage VI.

The stages recognized by the number of terminal spines on the telson are not so well defined as those recognized by the character and number of the pleopods. The range of size is bigger among the former so that they overlap more than do the latter. This is shown diagrammatically in Fig. 35 for the three species of which I saw large numbers of larvae. The columns show the range of the lengths of the individuals of each stage; the

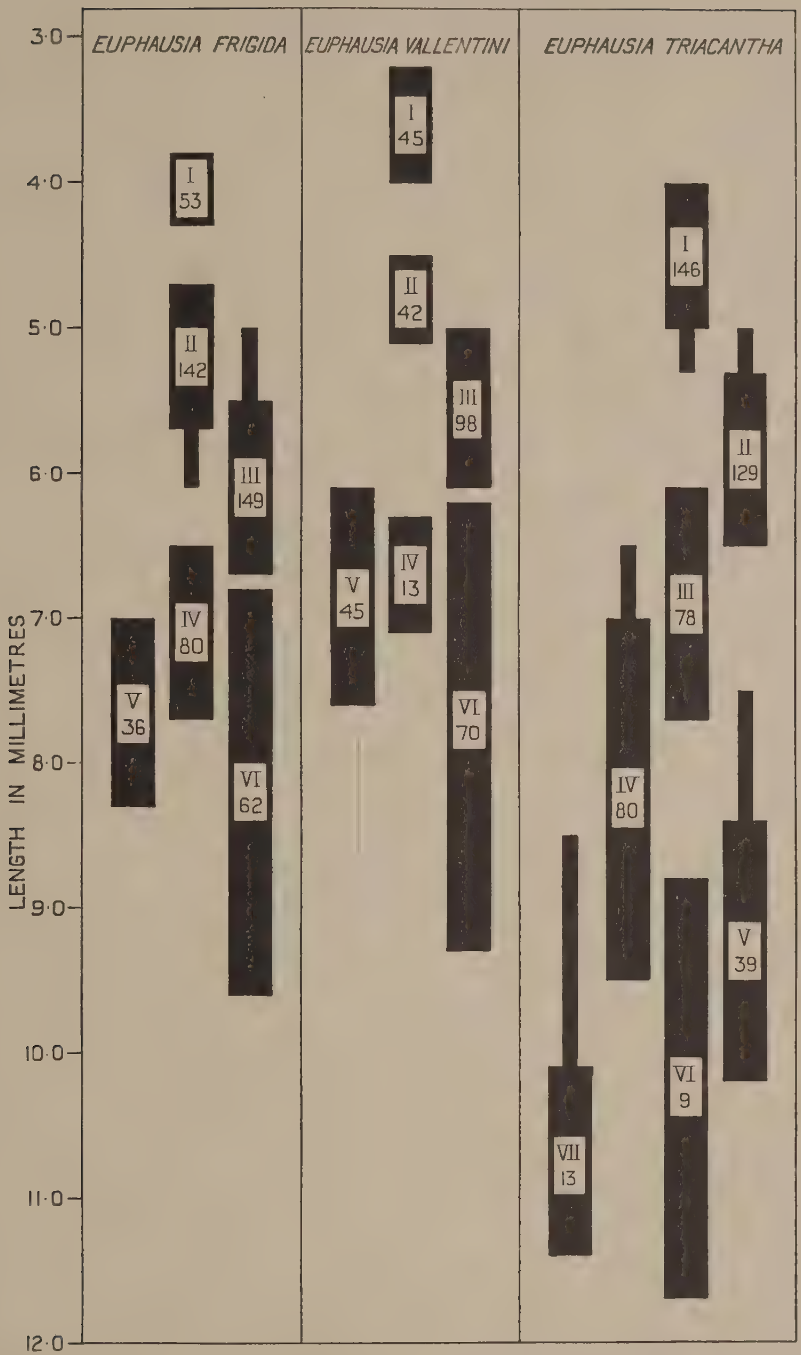

Fig. 35. Diagram showing the range of lengths of the Furcilia stages of *E. frigida*, *E. vallentini* and *E. triacantha*. Explanation given in the text.

majority of the individuals fall within the lengths shown by the thicker part of the column, very few within those shown by the thin—often one individual only, of the length indicated by the end of the thin part. The number of the Furcilia stage and the number of the individuals measured are inserted in each column.

The range of development in the individuals falling within one of the later stages is bigger than that in those of an earlier stage. A particularly big range was found in the latest stages of *E. triacantha*, even though I saw fewer numbers of them than of the corresponding stages of the other two species. In an exceptionally small individual of stage VII the gills were no farther developed than is usual for stage IV (see p. 285). This overlapping in range of size and degree of development is no doubt to be accounted for by the fact that in some individuals the reduction in the number of terminal spines does not follow the path that it follows in the majority: from seven to five, five to three and three to one. From a small sample of *E. vallentini* with seven terminal spines it was seen that some would have but three in the succeeding moult (see above). It seems improbable that they would then be as far developed in other ways as three-spined specimens that had passed through a five-spined moult. If this is right the Furcilia stages recognized by the number of terminal spines on the telson are not such natural groups as those recognized by the character and number of the pleopods. Fraser (1936, p. 40) expresses the opinion that the Euphausiacea "are arthropods in which continuous development is giving way to metamorphosis—already well defined in the Nauplius, Metanauplius and Calyptopis stages, less well defined in early Furcilia by the presence of dominant forms and still less intelligible in later development".

POST-LARVAL DEVELOPMENT

Fraser's latest Furcilia stage in *E. superba*, and mine in my five species, is that having one terminal spine and the original three pairs of postero-lateral spines, however modified, on the telson. If we were in accord with earlier workers our latest Furcilia stage would be the same as their latest Cyrtopia stage. In this we are in accord, at least in part, with Sars. Although his definition of the Cyrtopia (1885, p. 150) does not make it clear where that stage ends, his definition of the post-larval stage which follows, does: "All the legs developed. *Telson assuming its definitive form and armature*."[1] He describes the telson of the last Cyrtopia of *E.* ? *krohnii* (p. 164, *sub E. pellucida*) as still having three pairs of postero-lateral spines, and figures the telsons of the last Cyrtopia and the first post-larval stage of *Thysanopoda tricuspidata* (pl. xxxi, figs. 21, 22) as having, respectively, three pairs and two pairs of postero-lateral spines.

Other workers have not retained this division between the Cyrtopia and the post-larval stages. Lebour (1925, p. 811) wrote:

> Sars regards the post-larval stage as having all the limbs fully formed, and only differing from the adult in the absence or presence of certain setae. The present observations show, however, that the Cyrtopia merges imperceptibly into the adult, and that both male and female may be mature before the

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[1] The italics are mine.

appendages are fully formed as far as the exopodite of the male seventh thoracic limb is concerned, and also the number of gill-lobes in both sexes. It has, therefore, been thought advisable to omit the term post-larval altogether, and regard the late Cyrtopia to be the direct predecessor of the adult.

Lebour, Macdonald, Rustad and Frost described as Cyrtopia stages the whole series of moults between their last Furcilia and the adult; none of them fixed an easily recognized upper limit to the Cyrtopia.

I suggest that the term post-larval should be brought into use again; it is convenient, for the species described in this paper and for a number of others, to regard the larval stages as ending at that point where the three pairs of postero-lateral spines of the telson become reduced to two by the disappearance of the middle pair (the "outer long lateral spines" of Lebour, Macdonald and Frost). The preceding pages have shown that up to that point it is easy to recognize successive stages, first by the pleopods, then by the terminal spines of the telson. There is no such easy way of recognizing later stages: they "merge imperceptibly into the adult"; and in doing so they soon acquire some of the characters of the adult and may be recognized by them. For example: *Euphausia krohnii* shows in the last stage in which it has three pairs of postero-lateral spines the antennular lappet developing towards its adult and characteristic form; at a slightly later stage *E. vallentini* shows the beginnings of the spine on the third abdominal segment; both *E. longirostris* and *E. spinifera* develop the antennular lappets and spines on the fourth and fifth abdominal segments. I have called those forms which follow the last stage to have three pairs of postero-lateral spines on the telson (my last Furcilia stage) post-larval forms, but I have made no attempt to describe the successive moults which take place.

The last Furcilia in each of my five species has one terminal spine and three pairs of postero-lateral spines on the telson. There is such a stage in each of the following euphausiids:

Thysanopoda aequalis (Lebour, 1926 *c*, p. 770).
Nyctiphanes couchii (Lebour, 1925, pl. ii, figs. 7, 8).
Thysanoessa inermis (Lebour, 1926 *a*, pl. iv, figs. 9, 10).
T. raschii (Macdonald, 1928, p. 64).
T. macrura (Rustad, 1930, fig. 45 *a*).
Euphausii krohnii (Frost, 1934, fig. 9 *B*).
E. superba (Fraser, 1936, p. 97).

In the development of twelve euphausiid species then, of four genera, the middlemost of the three pairs of postero-lateral spines is not lost until after the number of terminal spines is reduced to one. But in one species it is known to be otherwise: in *Meganyctiphanes norvegica* (Lebour, 1925, p. 826, pl. ix, figs. 8, 9) the middlemost pair of postero-lateral spines is lost while the telson still has three terminal spines. In this species I would suggest that the point at which the number of terminal spines is reduced to one would most suitably be regarded as dividing larval and post-larval forms. It is clear that no general rule, based on characters chosen because they are easy to recognize, can be laid down for separating larvae from adolescents in Euphausiidae.

In the species described in this paper and in *Euphausia superba*, *E. krohnii*, *Thysanoessa macrura*, *T. raschii* and *Meganyctiphanes norvegica*, the number of terminal spines on the telson does not begin to be reduced until, or until after, all the pleopods become setose. But this is not invariably so in euphausians: in *Thysanopoda aequalis* and in *Nematoscelis microps* the development of the pleopods is accompanied by a reduction in the number of terminal spines from the original seven (Lebour, 1926 *c*, pp. 770, 768). Lebour's descriptions of the larvae of these two species interpreted in terms of Furcilia stages as used in this paper are tabulated below.

Table III

	Furcilia				
	Stage I	Stage II	Stage III	Stage IV	Stage V
Thysanopoda aequalis: Pleopods	None	2 non-setose	2 setose, 2 non-setose	4 setose, 1 non-setose	5 setose
Terminal spines of telson	7	5	3	3	1 (and either 3 or 2 pairs postero-lateral)
Nematoscelis microps: Pleopods	1 non-setose	1 setose, 3 non-setose	4 setose, 1 non-setose	5 setose	—
Terminal spines of telson	"7 giving rise to 5"	"7 giving rise to 3"*	"3 giving rise to 1"	1 (and 3 pairs of postero-lateral)	[Next stage: 2 pairs of postero-lateral]

* Lebour (*ibid.*, p. 768) writes: "In the second Furcilia (stage I above)...there are seven giving rise to five....This may, however, be abnormal, for in the sixth Furcilia (stage II)...there are specimens with seven spines giving rise to three...." I presume there were also specimens with five terminal spines.

It would be interesting to know the state of development of all the appendages of the stage with one terminal spine and three pairs of postero-lateral spines in the two species (stage V of *Thysanopoda aequalis* and stage IV of *Nematoscelis microps*). The thoracic limbs and the gills of this stage of the five species of *Euphausia* whose development is described in this paper are at roughly the same point as one another in development. It may be that the whole development is speeded up in *Thysanopoda aequalis* and *Nematoscelis microps*; that not only is the telson modified earlier than in other species but that the appendages develop earlier too.

It has already been shown that in a number of euphausiids the comparative development of the Furcilia is roughly the same: first the pleopods successively appear, and then the telson becomes modified;[1] but that at the same time the steps along the first part of the path of development might be different in different species. It now appears possible that in other euphausians the comparative development may be very different.

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[1] At the same time, in the five *Euphausia* described here, the thoracic appendages develop in each at *roughly* the same rate.

Table IV. *Showing the paths of Furcilia development in various species of euphausians*

	Endopod of antenna not segmented Number and character of the pairs of pleopods														Endopod of antenna segmented Number of terminal spines on telson			
	None	1 non-setose	2 non-setose	3 non-setose	4 non-setose	5 non-setose	1 setose 2 non-setose	1 setose 3 non-setose	1 setose 4 non-setose	2 setose 2 non-setose	2 setose 3 non-setose	3 setose 2 non-setose	4 setose 1 non-setose	5 setose	7	5	3	1
Thysanopoda aequalis [Lebour]	I (7)	—	II (5)	—	—	—	—	—	—	III (3)	—	—	IV (3)	V (1)	—	—	—	—
Nematoscelis microps [Lebour]	—	I (7)	—	—	—	—	—	II (7) (? 5)	—	—	—	—	III (3)	IV (1)	—	—	—	—
Nematoscelis megalops [Frost, 1935]	—	—	I (7)	—	—	—	—	—	—	—	II (7)	—	—	III (5)	Later development imperfectly known			
Stylocheiron longicorne [Frost, 1935]	I (7)	II (7)	—	—	—	—	III (7)	—	—	—	—	IV (7)	—	V (7)				
Meganyctiphanes norvegica [Lebour, Macdonald]	+	+	+	I (7)	+	—	—	+	—	+	+	II (7)	+	III (7)	—	? IV	? V	? VI
Thysanoessa macrura [Rustad]	I (7)	—	—	—	—	II (7)	—	—	—	—	—	—	—	III (7) (5)	—	IV	V	VI
Euphausia krohnii [Lebour, Frost]	—	I (7)	—	—	—	—	—	—	II (7)	—	—	—	—	III (7)		IV	V	VI
Euphausia frigida [Rustad, John]	—	—	—	+	I (7)	+	—	—	—	—	—	—	II (7)	III (7)	—	IV	V	VI
Euphausia vallentini	—	—	—	—	I (7)	—	—	—	—	—	—	+	II (7)	III (7) (5)	—	IV	V	VI
Euphausia triacantha	—	—	—	—	I (7)	+	—	—	—	—	—	+	II (7)	III (7)	IV	V	VI	VII
Euphausia longirostris	—	I (7)	—	—	—	—	—	II (7)	—	—	—	—	III (7)	IV (7)	—	V	VI	VII
Euphausia spinifera	—	I (7)	—	—	—	—	+	II (7)	—	—	—	—	III (7)	IV (7)	—	V	VI	VII
Euphausia superba [Fraser]	+	+	+	+	Dom.	Dom.	+	+	+	+	+	+	Dom.	Dom. *A*	*B*			
	I (7)						II (7)								III (7)	IV	V	VI

The Furcilia stages of each species are shown by successive roman numerals; in those distinguished by the number and character of the pleopods the number of terminal spines on the telson is shown in brackets after the number representing the stage. Where Furcilia forms other than those that are the stages are known to occur they are shown by crosses (+). The authorities and references for all species but *Nematoscelis megalops* and *Stylocheiron longicorne* have already been given in the text.

In the data for *Euphausia superba*: Dom. = dominant; *A* = postero-lateral spines unaltered; *B* = postero-lateral spines altered (see footnote p. 255, and Fraser, 1936, p. 49).

The different paths that development takes in the species for which it is known are shown in Table IV. Other forms of Furcilia than those shown as stages occur in most of the species; it may be that in those I have interpreted here in terms of our Furcilia stages from the writings of others they occur in numbers large enough, if they were known, to make necessary some less simple interpretation of the path of development. It may be found that there are two instars where it appears that there is only one—as Fraser found that the Furcilia of *Euphausia superba* with five setose pleopods and seven terminal spines are composed of two stages. But the path of development shown for each species, even if it conceals a step by showing two steps as one, and even though some individuals develop along other paths, is the one followed by most of the individuals of the species.

Euphausia triacantha, *E. longirostris* and *E. spinifera* are closely allied species forming with *E. hanseni* a natural group within the genus. *E. spinifera* lives in the sub-Tropical Zone, *E. longirostris* in the sub-Antarctic, and *E. triacantha* in the higher (the colder) sub-Antarctic and the Antarctic Zones. It is interesting to note that *E. triacantha* has a different path of Furcilia development to its allies.

Descriptions of the larval development of five species of *Euphausia* follow. All the measurements are of material preserved in formalin. I have followed English writers in calling the first thoracic limb by that name, and those that follow, the second to eighth. Scandinavian writers have called the first limb the maxilliped, and those following, the first to seventh thoracic limbs.

Development of **Euphausia frigida**

Rustad (1930) described most of the larval forms of *E. frigida*, none of which had been recognized before. He had large numbers (110) of the three Calyptopis; smaller numbers (21) of the earlier Furcilia, my stages I–III; and small numbers (12 only) of the later Furcilia, his Cyrtopia—my Furcilia stages V and VI. Ruud (1932, p. 52, table 13) recorded a smaller collection of larvae, richer like Rustad's in Calyptopis than in later stages. Rustad's Furcilia, especially the later, were not numerous enough for him to recognize the steps by which development proceeds, but in a later paper (1934, p. 15) he showed that the seventy-five earlier Furcilia of a larger collection fell into three groups—my Furcilia stages I, II and III.

The larval forms and the numbers of each that I found are as follows:

Calyptopis:	Second	23
	Third	50
Furcilia:		
	With 3 pairs of non-setose pleopods	1
Stage I.	With 4 pairs of non-setose pleopods	123
	With 5 pairs of non-setose pleopods	1
Stage II.	With 4 pairs of setose, 1 pair of non-setose pleopods	194

Stage III.	With 5 pairs of setose pleopods, antennal endopod unsegmented, 7 terminal spines on telson	220
	With 5 pairs of setose pleopods, antennal endopod unsegmented, 5 terminal spines on telson	1
	With antennal endopod segmented, 7 terminal spines on telson	4
	With antennal endopod segmented, 6 terminal spines on telson	2
Stage IV.	With antennal endopod segmented, 5 terminal spines on telson	117
	With antennal endopod segmented, 4 terminal spines on telson	4
Stage V.	With antennal endopod segmented, 3 terminal spines on telson	44
	With antennal endopod segmented, 2 terminal spines on telson	10
Stage VI.	With antennal endopod segmented, 1 terminal spine on telson	98

All of these are from the Falkland Sector of the Antarctic.

Although Rustad (1930) has described the second and third Calyptopis stages, as well as the first of which I have none, I have thought it well to give my own descriptions of them in the terms and detail I use for describing later stages of this species and these and later stages of other species.

The larval stages of *E. frigida* are very similar to those of *E. vallentini*.

Second Calyptopis (Fig. 36 *a*)

Description based on the examination of eight specimens, 1·7–1·8 mm. long.[1]

The carapace is rounded anteriorly and is hood-like, coming down far in front and on either side of the head. It broadens out laterally from a point anterior to the middle point of the lateral margin. The upper hinder angle appears in side view to be faintly pointed because of the small and gently rounded projection in the middle of the posterior margin. There is no definite dorsal organ, but there may or may not be a small less characteristic projection in the region.

The antennular peduncle is of two or of three segments; the flagella are represented by small single segments. The other appendages, the antennae to the first thoracic limbs, are similar to those of other described Calyptopis. The limbless second to eighth thoracic segments are easily seen as narrow encircling folds of the integument.

The abdomen is of six segments and equal in length to the carapace. The posterior margin of the telson is rounded and there are seven terminal spines.

Third Calyptopis (Fig. 36 *b*)

Description based on the examination of seventeen specimens. Twenty-three were measured and were 2·5–2·9 mm. long.

The carapace seen from above or below, or better still at an oblique angle from above or below, is constricted immediately behind the eyes and then broadens out laterally and ventrally into faint postero-lateral wings. There is as in the preceding stage a low and gently rounded projection in the middle of the posterior margin. A denticle is present on each of the lateral margins near the posterior end. There may or may not be a small but definite projection in the region where the dorsal organ occurs in other species.

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[1] Rustad (1930) gives the length as about 1·5 mm.

The antennular peduncle is of three segments; the spine from the outer distal corner of the first is as long as, or more often longer than, the sum of the second and third segments.

Small sac-like buds of the second, or of the second and third, or even of the second, third and fourth thoracic limbs, are present, the second bigger than the third and so on; they are enclosed in a common integument, not "free".

The abdomen is of seven segments and is one and a half times as long as the carapace. The postero-lateral corners of the telson are rounded, the posterior margin is straight or feebly convex and has seven terminal spines which become progressively smaller from the outside to the centre.

Furcilia, stage I (Figs. 36 *c–e*)

Description based on the examination of over forty specimens. Fifty-three were measured and were 3·8–4·3 mm. long.

In this stage there are four pairs of non-setose pleopods.

The carapace may have no dorsal organ or a diminutive dorsal organ or a small projection of a less definite and characteristic shape. The frontal plate is either rectangular, the anterior margin straight, the lateral margins parallel, the distal corners right angles, and the whole broader than long, or it is a little narrower distally than at the base so that the corners are not right angles and the whole is as long as broad. It is always broader and squarer than that of the same stage of *E. vallentini.*

The antennular spine is longer than, or equal in length to, the sum of the second and third peduncular segments.

The most usual condition of the thoracic limbs is that the buds of the second and third are free, the former beginning to bifurcate or bifurcated (Fig. 36 *e*) and a quarter to half the length of the first, the third about half the length of the second; the buds of the fourth to eighth are small and enclosed in a common integument. The bud of the second limb may be the only one free and may or may not be bifurcated.

There may or may not be a pair of small lateral projections from the tergum of the first abdominal somite, which are the beginnings of the "tergal wings" of the later stages and the adult.

The abdomen is one and two-thirds as long as the carapace. The uropods reach as far as the lateral spines of the telson.

Furcilia, stage II (Figs. 36 *f–h*)

Description based on the examination of forty specimens. One hundred and forty-two were measured; one was 6·1 mm. long but the others fell between 4·7 and 5·7 mm.[1]

In this stage there are four pairs of setose and one pair of non-setose pleopods.

The carapace may have no dorsal organ or projection, a small or, more frequently, very small dorsal organ (never so high and abrupt as that of *E. vallentini*), or a low projection. The frontal plate is usually wide with a rounded anterior margin sometimes

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[1] Rustad records a length so low as 4·2 mm.

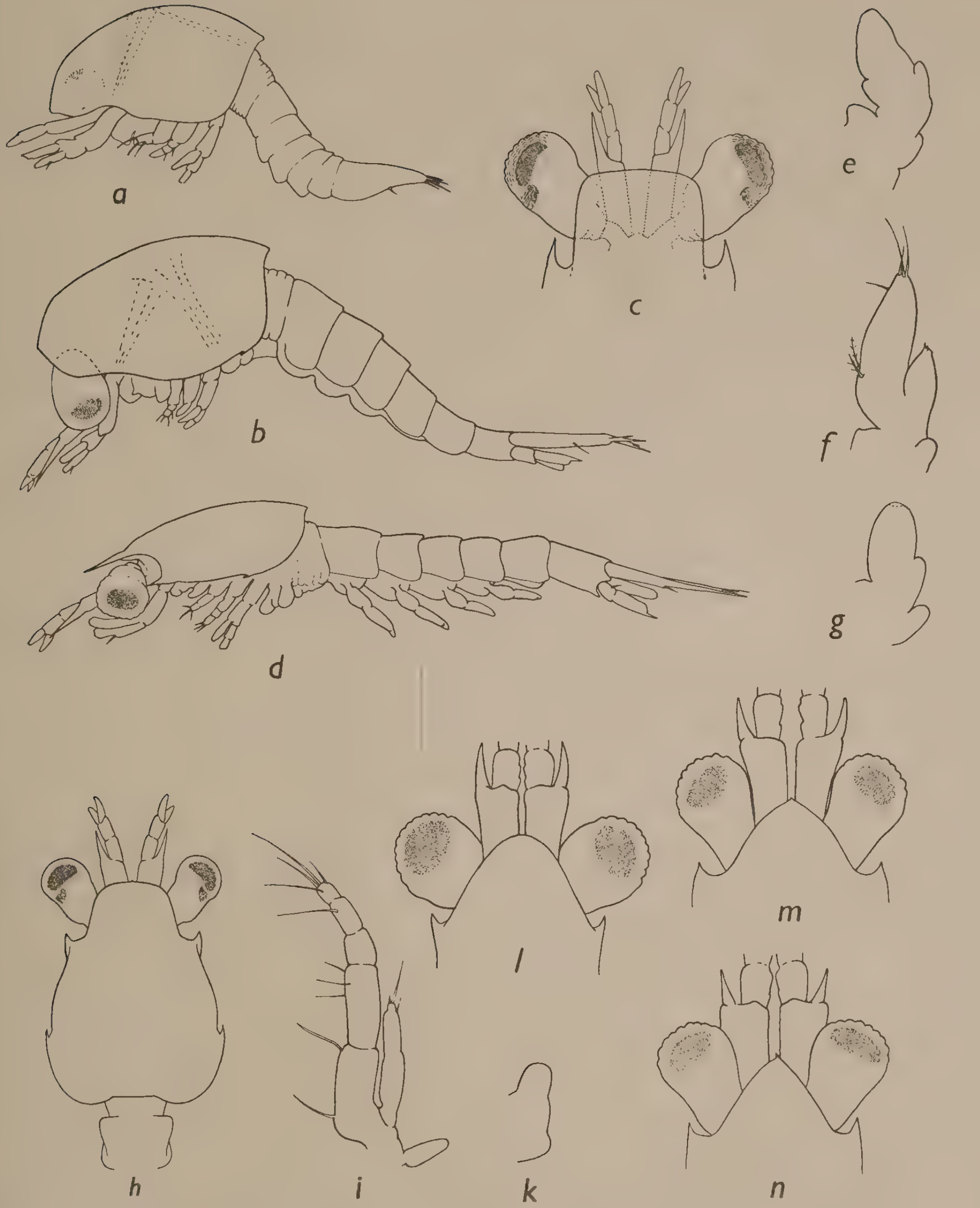

Fig. 36. *E. frigida. a*, second Calyptopis from the side, × 33. *b*, third Calyptopis from the side, × 33. *c*, Furcilia, stage I, frontal plate and antennules, × 40. *d*, Furcilia, stage I, from the side, × 27. *e*, Furcilia, stage I, second thoracic limb, × 53. *f*, Furcilia, stage II, second thoracic limb, × 53. *g*, Furcilia, stage II, fourth thoracic limb, × 53. *h*, Furcilia, stage II, anterior part from above, × 20. *i*, Furcilia, stage III, second thoracic limb, × 53. *k*, Furcilia, stage III, fifth thoracic limb, × 53. *l*, *m* and *n*, Furcilia, stage IV, frontal plate and antennules, × 27.

without, but mostly with a tiny spine at the centre; in the smaller the lateral margins are still nearly parallel and the anterior margin may be straight, but in the larger the plate narrows a little distally (Fig. 36 *h*). It does not approach the "rounded triangular" shape as in *E. vallentini*.

The antennular spine reaches as much as two-thirds or more of the way up the third peduncular segment; the flagella are unsegmented.

The development of the thoracic appendages varies from (i) Buds of second and third free, remainder low and in a common integument; second nearly as long as first, unsegmented but bifurcated, endopod with terminal and other setae, a very small gill bud (Fig. 36 *f*); third about half the length of second, less completely bifurcated and with no gill bud; to (ii) Buds of second, third and fourth free; second as long as first with its endopod of five segments, with a big gill bud; third half as long as second and bifurcated but not segmented, endopod with a terminal seta, with a gill bud; fourth beginning to bifurcate and to bud off a gill (Fig. 36 *g*). The majority lie between these two extremes having the buds of the second and third appendages free and that of the fourth becoming free, the second unsegmented, strong gill buds on the second and third.

The tergal wings of the first abdominal somite are well developed (Fig. 36 *h*), but they are not connected dorsally by a "collar" as in the same stage of *E. vallentini* (Fig. 37 *e*).

Furcilia, stage III (Fig. 36 *i*, *k*)

Description of thoracic appendages based on examination of twelve specimens, of other characters, of sixty specimens. One hundred and forty-nine were measured. One taken unusually late in the year (May 1) measured only 5·0 mm.; the remainder fell between 5·5 and 6·7 mm.[1]

In this stage there are five pairs of setose pleopods and the antennal endopod is unsegmented.

The carapace may have a crest too low to be called a dorsal organ or a small dorsal organ not so big nor so abrupt as that of the same stage of *E. vallentini*. The frontal plate is usually strongly rounded, though it does not narrow much distally, with a small spiniform process in the centre of its anterior margin; it may be broadly rounded with no spiniform process.

The antennular spine reaches about halfway along the third peduncular segment. The flagella are either unsegmented or beginning to segment and about equal in length to the sum of the second and third peduncular segments.

The degree of development of the thoracic limbs is as follows:

First limb. Endopod unsegmented as in the earlier larval stages.

Second limb. Considerably longer than the first, endopod of five segments and feebly kneed (Fig. 36 *i*).

Third limb. Endopod with five segments indicated or of five segments, much shorter than to knee of second or reaching to it.

[1] Rustad records one so small as 4·44 mm. taken in February in inshore waters.

Fourth limb. Considerably shorter than third, bifurcated, with endopod unsegmented and without or with terminal setae, a strong gill bud.

Fifth limb. Very short and not bifurcate, or bifurcate, a small or a strong gill bud (Fig. 36 *k*).

Sixth limb. A low unbifurcate bud, no gill bud or a small gill bud.

Seventh limb. Very rarely no gill bud, usually a small or a strong gill bud. The seventh gill bud appears before the sixth and is always bigger than it in this and the stages which immediately follow.

Eighth limb. Usually not developed, very rarely a small gill bud.

The tergal wings of the first abdominal somite are not connected dorsally by a collar as in this stage of *E. vallentini*.

Of the 239 specimens examined all but two had seven terminal spines on the telson; the two had five.

Furcilia, stage IV (Fig. 36 *l*, *m*, *n*)

Description based on the examination of twenty-three specimens. Eighty were measured and were 6·5–7·7 mm. long.

In this stage there are five pairs of setose pleopods, the antennal endopod is segmented and there are five terminal spines on the telson.

The carapace has a low and well-defined ridge, an ill-defined ridge, or more rarely no ridge, in the position of the dorsal organ. The frontal plate is rarely broad and evenly rounded with no central point, or triangular with strongly convex sides and a central point, or a sharply pointed triangle with feebly convex or straight sides (Fig. 36 *l*, *m*, *n*).

The antennular spine reaches up to halfway along the third segment of the peduncle.

The mandibular pulp is usually not segmented, rarely segmented.

The degree of development of the thoracic limbs is as follows:

First limb. Short. Endopod mostly with three, sometimes with four, rarely with five, segments. No gill bud.

Second limb. Endopod long and kneed.

Third limb. Endopod nearly as long as that of second, not kneed or feebly kneed.

Fourth limb. Endopod considerably shorter than that of third, divided sometimes into three, more usually into five segments.

Fifth limb. Bifurcate. Endopod rarely very short with only one or two terminal setae, most frequently longer with many setae but unsegmented; rarely segmented.

Sixth limb. Either a low bud beginning to bifurcate or short and bifurcate with no setae on endopod.

Buds of the second to eighth pairs of gills are present, usually unbranched, the seventh slightly bigger than all the others, the eighth sometimes very small. The sixth to eighth pairs may be beginning to branch; the seventh appears to be the first to show signs of branching.

The tergal wings of the first abdominal somite are not connected dorsally by a collar.

Furcilia, stage V

Description based on the examination of nine specimens. Thirty-six were measured and were 7·0–8·3 mm. long.

In this stage there are three terminal spines on the telson.

The carapace and frontal plate are as in the previous stage, the frontal plate being most often a triangle with straight sides.

The antennular spine is as long as, or a little shorter than, the second peduncular segment.

The mandibular palp may be either unsegmented or of two or three segments and setose.

The degree of development of the thoracic limbs is as follows:

First limb. Endopod of five segments and similar in shape to that of second but much shorter. No gill bud.

Third limb. Endopod nearly as long as that of second and kneed.

Fourth limb. Endopod considerably shorter than that of third but kneed.

Fifth limb. Endopod much shorter than that of fourth, of five segments but not kneed.

Sixth limb. From short bifurcate with endopod unsegmented but setose, to longer with endopod of three segments.

Buds of the second to eighth pairs of gills are present. The second to fifth are single, the sixth to eighth beginning to branch; or more often the second to fifth are single or beginning to branch, the sixth and eighth two-branched, the seventh three-branched. The new branches are in all much smaller than the buds from which they arise.

The tergal wings are not connected dorsally by a collar.

Furcilia, stage VI

Description based on the examination of fifteen specimens. Sixty-two were measured and were 6·8–9·6 mm. long.[1]

In this stage there is one terminal spine on the telson.

The carapace and frontal plate are similar to those in the two previous stages, the frontal plate being most often a triangle with straight sides.

The antennular spine is as long as, or a little shorter than, the second peduncular segment.

The mandibular palp is rarely not segmented nor setose, usually segmented and setose.

The degree of development of the thoracic limbs is as follows:

First limb. Endopod reaching well beyond knee of second. No gill bud or a very small gill bud.

Fourth limb. Endopod nearly as long as that of second.

[1] Rustad records one of only 6·0 mm

Fifth limb. Endopod of five segments, not kneed or kneed.

Sixth limb. Very rarely short, bifurcating and with endopod non-setose; usually longer or long with endopod setose and of two to five segments.

The first pair of gills may or may not be present as very small buds. Most frequently the second to fifth pairs are not branched or just beginning to branch, the sixth two-branched, the seventh and eighth three-branched. They may be less well developed: the second to fifth single, the sixth to eighth just beginning to branch; or the second to fifth single or just beginning to branch, the sixth and eighth two-branched, the seventh three-branched. They may be further developed: the second to fifth beginning to branch, the third more advanced than the second and so on, the sixth and seventh three-branched, the eighth four-branched; or the second to fifth as in the previous clause, the sixth three-branched, the seventh and eighth four-branched.

The tergal wings are not connected dorsally by a collar.

Development of **Euphausia vallentini**

No one has described any of the larval forms of *E. vallentini*. The following is a list of those that I have examined, with the numbers of each:

Calyptopis:	Second	25
	Third	50
Furcilia:		
Stage I.	With 4 pairs of non-setose pleopods	62
	With 3 pairs of setose, 2 pairs of non-setose pleopods	3
Stage II.	With 4 pairs of setose, 1 pair of non-setose pleopods	47
Stage III.	With 5 pairs of setose pleopods, antennal endopod unsegmented	135
Stage IV.	With antennal endopod segmented, 5 terminal spines on telson	20
	With antennal endopod segmented, 4 terminal spines on telson	12
Stage V.	With antennal endopod segmented, 3 terminal spines on telson	93
	With antennal endopod segmented, 2 terminal spines on telson	15
Stage VI.	With antennal endopod segmented, 1 terminal spine on telson	111

All came from immediately north of the Antarctic convergence between the Falkland Islands and South Georgia, i.e. from one sector of the sub-Antarctic Zone and from near the southern limit of the habitat of the species.

The larvae of *E. vallentini* are so similar in general appearance to those of *E. frigida* that they would be indistinguishable from them were it not for the dorsal organ of the carapace in all the stages described here, and the "tergal collar" of the Furcilia stages II–VI.

Second Calyptopis (Fig. 37 *a*, *b*)

Description based on the examination of twelve specimens. Twenty-one were measured and were 1·6–1·8 mm. long.

The carapace is similar to that of the same stage of *E. frigida* except that there is mostly, but not invariably, a small but distinct dorsal organ.

The appendages are as in the second Calyptopis stage of *E. frigida*, and the thoracic segments without limbs, the second to eighth, can be recognized as narrow encircling folds of the integument.

The abdomen is of six segments and slightly longer than the carapace. The telson has seven terminal spines (Fig. 37 *b*).

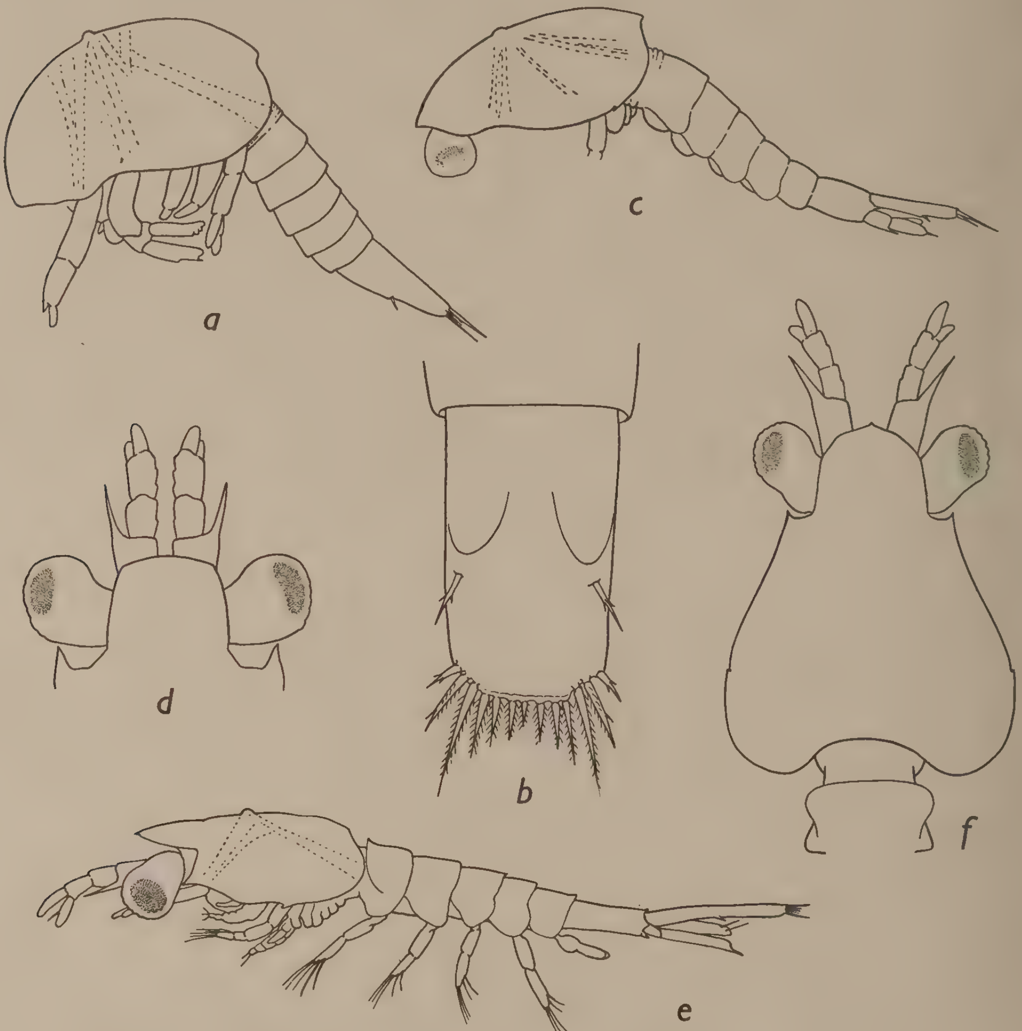

Fig. 37. *E. vallentini*. *a*, second Calyptopis from the side, × 47. *b*, second Calyptopis, telson from above, × 107. *c*, third Calyptopis from the side, × 30. *d*, Furcilia, stage I, frontal plate and antennules, × 57. *e*, Furcilia, stage II from the side, × 20. *f*, Furcilia, stage II, carapace and antennules from above, × 30.

Third Calyptopis (Fig. 37 *c*)

Description based on the examination of thirty-two specimens, 2·5–2·8 mm. long.

The carapace is similar to that of the third Calyptopis of *E. frigida* except that there is invariably a small but distinct dorsal organ present.

The antennular peduncle is of three segments, the spine from the first segment as long as the sum of the second and third.

The second, the second and third, or the second, third and fourth thoracic limbs are represented by sac-like buds, the second bigger than the third, and so on, enclosed in a common integument. The second may show the beginnings of bifurcation; the fourth appears to be more commonly represented by a bud than it does in the same stage of *E. frigida*.

The abdomen is of seven segments and one and a half times as long as the carapace. There are seven terminal spines on the telson which become progressively smaller from the outside to the centre.

Furcilia, stage I (Fig. 37 *d*)

Description based on the examination of thirty specimens. Forty-five were measured and were 3·2–4·0 mm. long.

In this stage there are four pairs of non-setose pleopods.

The carapace of all but a very few of those examined had a well-defined dorsal organ, an unmistakable abrupt protuberance. The frontal plate is rectangular with the distal corners nearly square in the smaller, more rounded in the larger. It is usually nearly as long as broad, rarely a little longer than broad (Fig. 37 *d*)—never so wide nor so square as in *E. frigida*.

The spine from the outer distal corner of the first antennular segment is usually nearly equal in length to the sum of the second and third segments, sometimes equal to it.

The most usual condition of the thoracic limbs is that the buds of the second and third are free (they are so in all thirty), and those of the fourth to eighth enclosed in a common integument; the second bifurcate, from a quarter to more than half the length of the first; the third not bifurcate. The third may be bifurcate and the bud of the fourth may be free; very rarely the second limb buds show the beginnings of gills.

Small lateral projections of the tergum of the first abdominal somite are present. The abdomen is nearly twice as long as the carapace. The uropods reach nearly to, or to the lateral spines of the telson.

Furcilia, stage II (Fig. 37 *e*, *f*)

Description based on the examination of twenty specimens. Forty-two were measured and were 4·5–5·1 mm. long.

In this stage there are four pairs of setose and one pair of non-setose pleopods.

The carapace has a conspicuous dorsal organ. The frontal plate narrows distally and is rounded so that it has the shape of a "rounded triangle". There is usually a diminutive spine in the centre of the anterior margin (Fig. 37 *f*). In some the spine is wanting and the shape is less nearly triangular.

The antennular spine reaches two-thirds of the way, or less frequently halfway, along the third peduncular segment; the flagella are short and unsegmented.

The buds of the second to fifth thoracic limbs are free. The degree of their development varies from (i) second bifurcate and nearly as long as first, endopod with terminal setae, gill bud present; third bifurcate and less than half length of second, with no setae, gill bud present; fourth not bifurcate, very short with no gill bud; fifth a very small simple bud; to (ii) endopod of second of five segments and nearly as long as first; third more than half length of second, endopod with terminal setae; fourth much shorter than third but bifurcate and beginning to bud off a gill; fifth showing the beginnings of bifurcation and the budding of a gill.

The tergal wings of the first abdominal somite are well developed and connected dorsally by an upstanding collar-like ridge. This tergal "collar" is very easily seen and it is the best character for distinguishing between this stage of *E. vallentini* and *E. frigida* (Fig. 37 *e* and *f*).

Furcilia, stage III

Description based on the examination of thirty specimens. Of ninety-eight specimens measured two were 5·0 mm., one was 5·2 mm. and the remainder 5·4–6·1 mm. long.

In this stage there are five pairs of setose pleopods and the antennal endopod is unsegmented.

The carapace has a prominent and unmistakable dorsal organ. The frontal plate is most frequently triangular with strongly or moderately convex sides; it is sometimes rounded with a central spine, more rarely rounded with no central spine.

The antennular spine reaches about halfway along the third peduncular segment. The flagella are either unsegmented or beginning to segment and about equal in length to the sum of the second and third peduncular segments. The mandibular palp is unsegmented.

The degree of development of the thoracic limbs is as follows:

First limb. Endopod of two segments as in earlier stages, no gill bud.

Second limb. Longer than first, endopod of five segments and feebly or strongly kneed.

Third limb. Endopod of five segments, usually not kneed and as long as to knee of second, sometimes longer and kneed.

Fourth limb. Endopod not segmented, or beginning to segment, terminal and other setae, one-third to more than half as long as third, a strong gill bud.

Fifth limb. Bifurcate, without or with setae, one-third to more than half as long as fourth, a gill bud.

Sixth limb. A low bud rarely bifurcate but usually with a small gill bud.

Seventh limb. A gill bud usually, but not always, developed.

Eighth limb. Usually not developed, rarely a small gill bud.

The tergal wings of the first abdominal somite are joined dorsally by a collar as in the previous stage.

There may be seven, six or five terminal spines on the telson. Of the specimens examined forty-seven had seven terminal spines, seven had six and fifty-seven had five (see Table I, p. 256 and pp. 257–8).

Furcilia, *stage IV*

Description based on the examination of ten specimens. Thirteen were measured and were 6·3–7·1 mm. long.

In this stage the antennal endopod is segmented and there are five terminal spines on the telson.

The carapace has a prominent and unmistakable dorsal organ, quite unlike anything seen in this stage of *E. frigida*. The frontal plate is triangular with feebly convex or straight sides.

The antennular spine varies from being a little longer to a little shorter than the second segment of the peduncle. The mandibular palp is unsegmented.

The degree of development of the thoracic limbs is as follows:

First limb. Endopod varies from having more than two segments indicated to being of five segments but not kneed; no gill bud.

Second and third limbs. Endopods long and kneed.

Fourth limb. Endopod of five segments, short and not kneed or longer and feebly or strongly kneed.

Fifth limb. Varies from being short unsegmented but setose to having an endopod of five segments which is not kneed.

Sixth limb. Usually very short and non-setose, rarely having an endopod with three segments indicated or completely marked off.

There are seven pairs of gills, the second to the eighth, present. They may all be of single buds, the eighth pair small; the second to fifth may be branching, the sixth and eighth single; the second to fourth may each have a small branch, the fifth be branching, the sixth and eighth of two branches and the seventh of three.

The collar joining the tergal wings of the first abdominal somite is not so high mid-dorsally as in the previous stage but it is distinct and characteristic enough to serve to distinguish this stage from the same stage of *E. frigida*.

Furcilia, *stage V*

Description based on the examination of thirty-five specimens for all but the development of the gills for which twenty were examined. Forty-five specimens were measured and were 6·1–7·6 mm. long.

In this stage there are three terminal spines on the telson.

The carapace has a prominent and unmistakable dorsal organ which is, however, a little lower in the larger specimens than in the smaller. The frontal plate is triangular with feebly convex, or more often, straight sides.

The antennular spine is usually as long as the second peduncular segment. The mandibular palp is either unsegmented or of three segments and setose.

The degree of development of the thoracic limbs is as follows:

First limb. Either short, the endopod having five segments indicated, or longer, the endopod having five segments; usually there is no gill bud but there may be one.

Fourth limb. Endopod nearly as long as that of third and strongly kneed.

Fifth limb. Varies from having an endopod of three segments to having one of five which is feebly kneed but considerably shorter than that of the fourth.

Sixth limb. Rarely not segmented and non-setose, most frequently not segmented but setose, often with endopod having three to five segments indicated.

There are always seven pairs of gills, the second to the eighth; the first pair may or may not be present as small buds. The following appears to be the most usual stage of development: the second to sixth and the eighth gills of buds of one small branch, the seventh of buds with two small branches arising from them. A variety of higher stages of development occurred which showed that the order in which the gills branch is not the same in all individuals. The highest development seen was the second to fifth gills of two, the sixth to eighth of three, strong branches.

The tergal collar of the first abdominal somite is the same as in the previous stage.

Furcilia, stage VI

Description of more general characters based on the examination of sixty-four specimens, of the mandibular palp on twenty specimens, of the limbs and gills on fourteen. Seventy specimens were measured and were 6·2–9·3 mm. long.

In this stage there is one terminal spine on the telson.

The carapace may have as strong and distinctive a dorsal organ as in earlier stages, or a smaller dorsal organ or only a crest; even if it is only a crest it is higher and more definite in form than anything which occurs in this stage of *E. frigida*. The frontal plate is a triangle with straight margins or a lower triangle in which the lateral margins are distally slightly concave.

The antennular spine is nearly as long as, or much shorter than, the second peduncular segment. The mandibular palp may be unsegmented but is usually segmented.

The degree of development of the thoracic limbs is as follows:

First limb. Either short with no gill bud, the endopod feebly kneed, or longer with a very small or small gill bud and the endopod strongly kneed.

Second to fifth limbs. Endopods long and kneed.

Sixth limb. Endopod of two to five segments and not kneed, or of five segments and kneed.

The first pair of gills may or may not be present as small buds. The second to fifth may each consist of two unequal branches, the sixth of two, and the seventh and eighth of three, roughly equal branches; or the second to fifth may consist of two nearly equal branches, the sixth to eighth of three unequal branches; or the second to fifth may consist of two equal and one much smaller branch, the sixth of three, the seventh of four, the eighth of five, unequal branches.

The tergal collar of the first abdominal somite is most frequently similar to that of the two previous stages; it is sometimes absent, so that no connection between the tergal wings can be seen.

Post-Larval Stages

Sixty-seven specimens of post-larval stages, all taken in one net haul in late February, were examined to discover at what size the tergal collar of the first somite of the abdomen, which serves to distinguish certain of the Furcilia stages from those of *E. frigida*, is lost; and at what sizes two structures characteristic of the adult, the broadly rounded antennular lappet and the spine of the third abdominal somite, appear. It was found that the tergal collar was absent from all and that the spine appeared before the lappet. An analysis of the specimens is shown below in lettered groups and the lengths of those of each group in Table V. Groups *A*, *B* and *C* were measured with greater accuracy than the larger individuals of groups *D* and *E*.

A. Without the beginnings of the abdominal spine	18 specimens.
B. With the beginnings of an abdominal spine: a small projection only ...	11 specimens.
C. With a well-developed abdominal spine but with no lappet, or with the small beginnings of a lappet...	13 specimens.
D. With lappet less than, or about, half-formed	16 specimens.
E. With lappet of shape and proportions of the adult	9 specimens.

Table V. *Showing lengths (in mm.) and numbers (in brackets) of post-larval* E. vallentini, *arranged according to the development of the abdominal spine and the antennular lappet*

A	*B*	*C*	*D*	*E*
6·5 (1)				
6·8 (1)				
7·3 (1)				
...	7·5 (1)			
7·6 (3)				
7·7 (1)				
...	7·8 (1)			
8·0 (3)	8·0 (1)			
8·1 (2)				
8·2 (1)	8·2 (2)			
8·3 (2)	8·3 (1)			
...	8·4 (1)			
8·5 (2)	8·5 (1)			
8·6 (1)	8·6 (1)			
	8·8 (1)			
		9·0 (1)		
	9·2 (1)			
		9·5 (1)		
		10·0 (2)		
		10·1 (1)		
		10·2 (1)		
		10·4 (2)		
		10·5 (2)		
		10·6 (1)		
		10·7 (2)		
			12 (4)	
			13 (5)	
			14 (5)	14 (2)
			15 (2)	15 (1)
				16 (1)
				17 (2)
				18 (3)

The smallest post-larval stages, Group *A* above, having lost the tergal collar of the Furcilia stages and not yet having begun to develop the third abdominal spine of the adult, might be very difficult to distinguish with certainty from early post-larval stages of *E. frigida* if they were taken from on or near the Antarctic convergence at a point where there had been some mixing of the surface waters of the Antarctic and sub-Antarctic Zones (see p. 204).

DEVELOPMENT OF **Euphausia triacantha**

The euphausian larvae described by Tattersall (1908, p. 21) as having a short blunt posterior spine on the carapace and a smooth anterior margin are undoubtedly of *E. triacantha*. Rustad (1930, pp. 54–7, figs. 35–7) described the first larval form of *E. triacantha* as such, a Furcilia with four pairs of setose and one pair of non-setose pleopods, from one specimen. In a later paper (1934, pp. 19–25, figs. 3–7) he described the first, second and third Calyptopis stages from five, eighteen and six specimens respectively, and a "Cyrtopia" with seven terminal spines on the telson (my Furcilia stage IV) from one specimen.

The stages and the numbers of each that I found are as follows:

CALYPTOPIS:	Second	25
	Third	95
FURCILIA:		
Stage I.	With 4 pairs of non-setose pleopods	310
	With 5 pairs of non-setose pleopods	5
	With 3 pairs of setose, 2 pairs of non-setose pleopods	1
Stage II.	With 4 pairs of setose, 1 pair of non-setose pleopods	343
Stage III.	With 5 pairs of setose pleopods, antennal endopod unsegmented	247
	With antennal endopod segmented, 8 terminal spines on telson	2
Stage IV.	With antennal endopod segmented, 7 terminal spines on telson	136
	With antennal endopod segmented, 6 terminal spines on telson	11
Stage V.	With antennal endopod segmented, 5 terminal spines on telson	71
	With antennal endopod segmented, 4 terminal spines on telson	1
Stage VI.	With antennal endopod segmented, 3 terminal spines on telson	11
	With antennal endopod segmented, 2 terminal spines on telson	3
Stage VII.	With antennal endopod segmented, 1 terminal spine on telson	16

The vast majority came from either side of the Antarctic convergence between the longitudes of the South Sandwich Islands and Cape Horn.

The larvae of *E. triacantha* can easily be distinguished from all other euphausian larvae occurring in the same waters.

Second Calyptopis (Fig. 38 *a*)

Description based on the examination of seven specimens. Fourteen were measured and were 1·9–2·3 mm. long.

The carapace is high and domed, the dome surmounted by a dorsal organ; the anterior margin is gently rounded; the lateral margins broaden out strongly behind the level of the eyes to form strong postero-lateral wings. There is a short but stout posterior projection from the middle of the hinder edge of the carapace.

The antennular peduncles are sometimes unsegmented, but are most often of two, sometimes of three, segments. The flagella are represented by small single segments.

The antennae, mandibles, first and second maxillae and first thoracic limbs are present as in other species of *Euphausia* for which this stage is known and are of similar structure. The thoracic segments without limbs are clearly visible as encircling folds of the integument.

The abdomen is of six segments. The telson has seven terminal spines decreasing in size from the outer to the inner, each having a row of spinules along each lateral margin. The three postero-lateral spines increase in size from the outer to the inner and each has a secondary spine, apart from spinules, arising from it.

Third Calyptopis (Fig. 38 *b*)

Description based on the examination of fifteen specimens. Thirty-three were measured and were 3·0–3·6 mm. long.

The carapace rises dome-like mid-dorsally to a point surmounted by a large and conspicuous dorsal organ. It is very broad anteriorly, with the margin gently rounded, usually with a tiny spine in the centre; it is arched over each eye, constricted behind the eyes and then widened out into the postero-lateral wings. There is a strong median projection from the posterior margin which rises dorsally. A pair of lateral denticles is present.

The antennular peduncle is of three segments; the spine arising from the outer distal corner of the basal segment is considerably longer than the sum of the second and third segments.

Buds of the second thoracic limbs are usually, though not invariably, present as large conical protuberances.

The abdomen is of seven segments. The posterior lateral margins of the sixth segment are produced backwards to form a pair of short spines, one running down either side of the telson; they become longer in the Furcilia and are present in post-larval stages but not in adults. The telson is broader than in the second Calyptopis; the terminal spines remain unchanged. The innermost of the postero-lateral spines is the longest, the outer the shortest; each of the three has a secondary spine arising from it; the inner two, but not the outer, have a row of spinules along the inner margin.

Furcilia, stage I (Fig. 38 *c*)

Description based on the examination of twenty specimens. One hundred and forty-six were measured and were 4·0–5·3 mm. long.

In this stage there are four pairs of non-setose pleopods.

The frontal plate is shield-like with the centre of its rounded anterior margin produced into a short but strong spine, the rostral spine. The carapace has a very conspicuous dorsal organ. Its median posterior projection has a wide base and it reaches well beyond the hinder margins of the postero-lateral wings.

The antennular spine is as long as in the third Calyptopis; the flagella are unsegmented.

The degree of development of the thoracic limbs is as follows:

Second limb. Long and bifurcate, the endopod with terminal setae; a strong gill bud.

Third limb. Usually short, about half as long as second, showing beginnings of budding off of exopod and gill at once; less often, longer and bifurcate, non-setose, with a small gill bud.

Fourth limb. Always free. Usually simple and less than half as long as third, sometimes beginning to show that exopod and gill will be budded off together.

Fifth limb. Not free.

There is a pair of very small lateral protuberances from the tergum of the first abdominal somite, the beginnings of the tergal wings of the adult (Fig. 38 *c*). There may be no posterior dorsal spines on the third to fifth abdominal somites, or very small spines on the fourth and fifth, or on all three.

The telson is similar to that of the third Calyptopis.

Furcilia, stage II

Description based on the examination of ten specimens. One hundred and twenty-nine were measured and were 5·0–6·5 mm. long.

In this stage there are four pairs of setose and one pair of non-setose pleopods.

The frontal plate is a little reduced in width and length compared with the previous stage, the rostral spine is stronger: this is a process which is continued in each of the larval stages which follow. The rostral spine reaches nearly as far forward as the end of the basal segment of the antennular peduncle. The dorsal organ is very strong. The median posterior projection of the carapace has gone, leaving only a low rounding of the margin in its place.

The antennular spine is still longer than the sum of the second and third peduncular segments. The flagella are usually unsegmented, sometimes beginning to segment.

The degree of development of the thoracic limbs is as follows:

First limb. Endopod still of two segments as in earlier stages, usually only a little longer than exopod. No gill bud.

Second limb. Endopod of five segments and feebly kneed. A two-branched gill bud.

Third limb. Endopod with five or less segments indicated, or of five segments. Gill bud beginning to branch or of two branches.

Fourth limb. Short, bifurcate, endopod non-setose or setose. Gill bud unbranched or branching.

Fifth limb. Very short, non-setose, usually bifurcating and budding off a gill, or with a small gill bud.

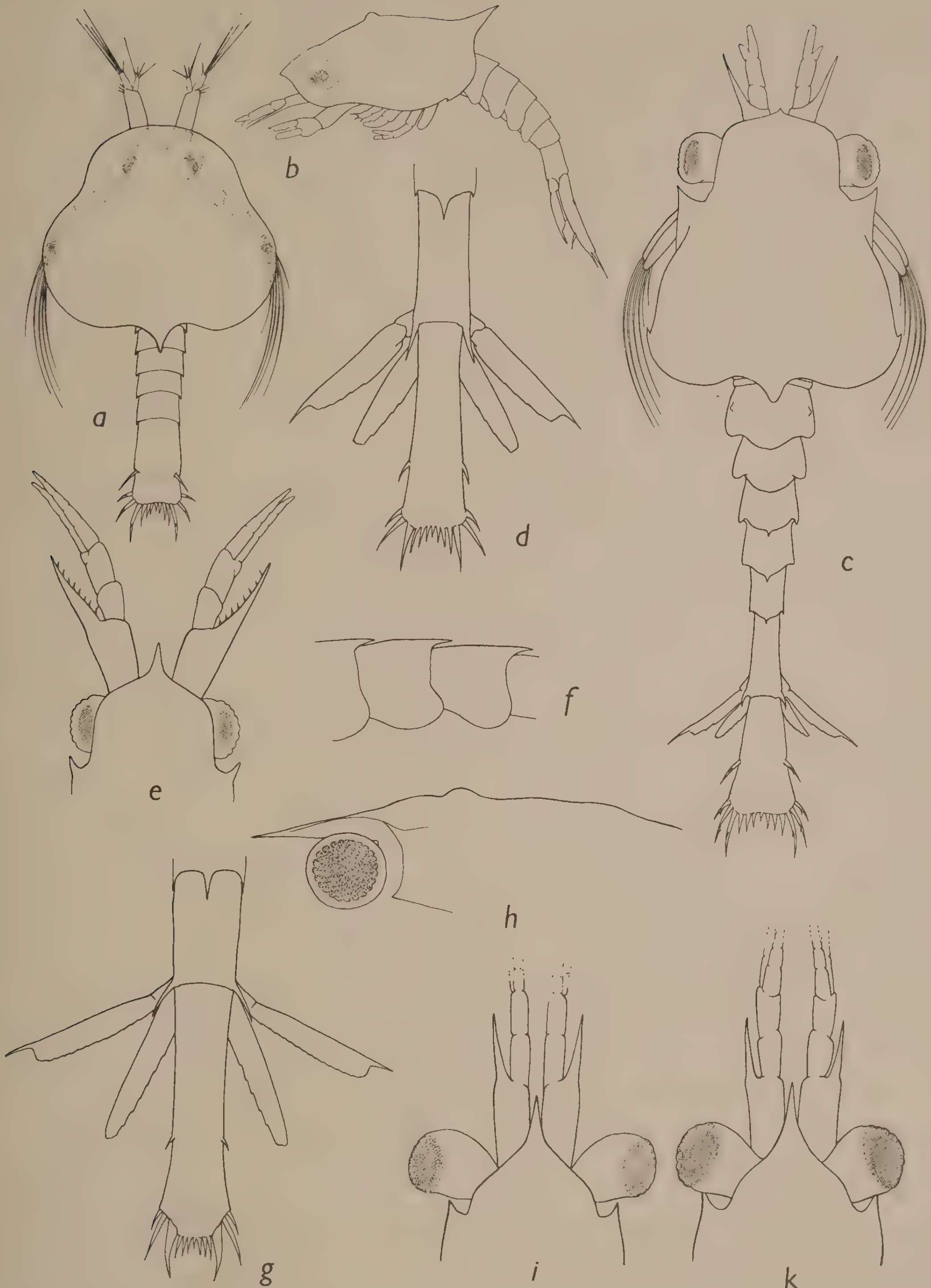

Fig. 38. *E. triacantha.* *a*, second Calyptopis from above, × 33. *b*, third Calyptopis from the side, × 22. *c*, Furcilia, stage I from above, × 30. *d*, Furcilia, stage III, telson from above, × 22. *e*, Furcilia, stage III, frontal plate and antennules from above, × 24. *f*, Furcilia, stage III, third to fifth abdominal segments from the side, × 30. *g*, Furcilia, stage IV, telson from above, × 27. *h*, Furcilia, stage V, front part of carapace from the side, × 27. *i*, Furcilia, stage V, frontal plate and antennules from above, × 24. *k*, Furcilia, stage VII, frontal plate and antennules from above, × 25.

Sixth limb. A low unbifurcate bud without or with a small gill bud.

Seventh limb. A strong gill bud.

The lateral protuberances of the first abdominal somite which appeared in the previous stage have developed into strong outstanding wings. The base of each lies obliquely on the tergum in a postero-ventral direction. These structures persist to the adult stage when their anterior ends overlap the margins of the postero-lateral wings of the carapace.

Each of the third to fifth abdominal somites has a posterior dorsal spine, the fifth the strongest, the third the weakest.

The telson is similar to that of the previous stage.

Furcilia, stage III (Fig. 38 *d*, *e*, *f*)

Description based on the examination of ten specimens. Seventy-eight were measured and were 6·3–7·7 mm. long.

In this stage there are five pairs of setose pleopods, but the antennal endopod is unsegmented.

The frontal plate is a little more reduced, the rostral spine a little stronger than in the previous stage. The spine reaches nearly as far, or as far, forward as the end of the basal segment of the antennular peduncle. The carapace has a strong dorsal organ; no trace of the median posterior projection of earlier stages remains: there is a deep depression in the margin in that region between the postero-lateral wings.

The antennular spine is as long as the sum of the second and third peduncular segments; the flagella are segmenting.

The mandibular palp is unsegmented.

The degree of development of the thoracic limbs is as follows:

First limb. Endopod as long as to knee of that of second limb, rarely of two segments, usually with three or more segments indicated. No gill bud.

Second limb. Endopod long and kneed. Gill either of two nearly equal branches, or of two nearly equal and a third smaller branch.

Third limb. Endopod shorter than that of second but kneed. Gill as in second limb.

Fourth limb. Endopod of five segments, not kneed or feebly kneed. Gill usually of two branches, rarely with a third smaller branch.

Fifth limb. Bifurcate. Endopod setose, not segmented or with segmentation indicated. Gill usually of two branches, rarely with a third smaller branch.

Sixth limb. Bifurcating or bifurcate, non-setose. A large gill bud budding off one or two small branches.

Seventh limb. A gill of two nearly equal branches and one or two smaller branches.

Eighth limb. A small gill bud which may be branching.

The tergal wings of the first abdominal somite may be unconnected, or they may be joined dorsally by a ridge of chitin or by an upstanding "collar" as in *E. vallentini*.

There is a strong posterior dorsal spine on each of the third to fifth abdominal somites as in the succeeding stages and the adult (Fig. 38 *f*).

The telson is narrower distally than in the previous stage and the innermost pair of postero-lateral spines, still the longest, are beginning to thicken at the base (Fig. 38 *d*).

Furcilia, stage IV (Fig. 38 *g*)

Description based on the examination of ten specimens. Eighty were measured and were 6·5–9·2 mm. long.

In this stage the antennal endopod is segmented and there are seven terminal spines on the telson.

The frontal plate is a little more reduced, the rostral spine a little stronger, than in the previous stage. The spine reaches as far forward as the end of the basal segment of the antennular peduncle. The carapace has a conspicuous dorsal organ.

The antennular spine is as long as the sum of the second and third peduncular segments.

The mandibular palp is elongated; it may be non-setose and not segmented or beginning to segment, but it is more often segmented and setose.

The degree of development of the thoracic limbs is as follows:

First limb. Endopod of five segments and long, reaching beyond knee of second, not kneed or feebly kneed. No gill bud.

Second to fourth limbs. Endopods long and kneed.

Fifth limb. Endopod considerably shorter than fourth, of five segments, not kneed or feebly kneed.

Sixth limb. Short. Endopod usually of three, sometimes of more segments, setose.

The first limb has no gill bud. Those of the second to fifth are of two nearly equal branches and a third smaller or much smaller branch. The sixth gill bud is of three nearly equal branches with or without a fourth and smaller branch. The seventh is of three larger and one or two smaller branches, or of four larger branches with or without the buds of other branches; the eighth of two nearly equal branches with or without buds of others.

The end of the telson is narrower than in the previous stage and the innermost of the three pairs of postero-lateral spines are still wider and stronger (Fig. 38 *g*).

Furcilia, stage V (Fig. 38 *h*, *i*)

Description based on the examination of ten specimens. Thirty-nine were measured and were 7·5–10·2 mm. long.

In this stage there are five terminal spines on the telson.

The frontal plate is further reduced, the rostral spine so strong that it is more appropriately called a rostrum. It reaches nearly to or to beyond the end of the first segment of the antennular peduncle; a strong crest runs centrally down it from the dorsal organ (Fig. 38 *h*, *i*).

The antennular spine is a little shorter than the sum of the second and third segments of the peduncle.

The mandibular palp is usually of three segments and setose.

The degree of development of the thoracic limbs is as follows:

First limb. Endopod of five segments, long and kneed, reaching well beyond knee of second.

Fifth limb. Endopod shorter than those of anterior limbs but kneed.

Sixth limb. Endopod of five segments but not kneed.

The development of the gills is as follows:

First gill. A small bud.

Second to fifth gills. Of three equal branches without or with another smaller branch.

Sixth gill. Of three larger branches and buds of others, or of four larger branches with or without the buds of others.

Seventh gill. Of four or five larger branches with the buds of others.

Eighth gill. Of two, three or more, usually four, larger branches and the buds of others.

The end of the telson is narrower, the innermost of the postero-lateral spines thicker, than in the previous stage. The latter have lost the spinules of their inner margins.

Furcilia, stage VI

Description based on the examination of nine specimens, 8·8–11·7 mm. long.

In this stage there are three terminal spines on the telson.

The frontal plate is a little reduced compared with that of the previous stage, the rostrum is as long. The dorsal organ may not be very distinct from the strong arched crest which runs forward from it to the rostrum.

The antennular spine is nearly as long as, or much shorter than, the sum of the second and third segments of the peduncle. The mandibular palp is segmented and setose.

The degree of development of the thoracic limbs is as follows:

First limb. Endopod shorter than that of second.

Fifth limb. Endopod kneed, much shorter than, to nearly as long as, that of fourth.

Sixth limb. Endopod much shorter than that of fifth but kneed.

The gills of five specimens were examined; in four they were as follows:

First gill. A small or large simple bud.

Second to fifth gills. Of three equal branches and a fourth smaller branch.

Sixth gill. Of four or five equal branches with buds of others.

Seventh gill. Of six roughly equal branches with buds of others.

Eighth gill. Of four, five or six roughly equal branches and buds of others.

In the fifth specimen, the smallest one seen, only 8·8 mm. long, the gills were less developed, corresponding most nearly with those of stage IV.

The telson is a little narrower, the innermost pair of postero-lateral spines a little longer and stronger, than in the previous stage.

Furcilia, stage VII (Fig. 38 *k*)

Description based on the examination of thirteen specimens, 8·5–11·4 mm. long.[1]

In this stage there is one terminal spine on the telson.

The frontal plate is a little smaller than in the previous stage; the rostrum reaches from nearly to, to beyond, the end of the first segment of the antennular peduncle. The dorsal organ and crest are as in the previous stage.

The antennular spine may be as long as or longer than the second segment of the peduncle. The beginnings of the lappet of the first segment may be present.

The thoracic limbs of twelve specimens, from 9·0 to 11·4 mm. long, were as follows:

First limb. Endopod nearly as long as that of second.

Fifth limb. Endopod long and kneed.

Sixth limb. Endopod as long as to knee of fifth or longer, feebly or strongly kneed.

In the smallest specimen taken, only 8·5 mm. long, the fifth limb is considerably shorter than the fourth, the sixth only half the length of the fifth and not kneed.

The gills of five specimens were examined. In four they were as in the five specimens of the previous stage; in the fifth as in the sixth specimen of the previous stage. It appears then that specimens of Furcilia stage VII may have gills no farther developed than those of stage IV.

DEVELOPMENT OF **Euphausia longirostris**

Dohrn (1871, pl. xxx, fig. 54) figured the second Calyptopis of *E. longirostris* without recognizing it as the larva of a euphausian; it is described as from the Indian Ocean. In the Challenger collection, Sars (1885, p. 170, pl. xxxi, figs. 30, 31) found and described a single specimen of a Furcilia with one pair of non-setose pleopods; he considered it to be a larva of a large species of *Euphausia*. Tattersall (1924, p. 22, pl. i, figs. 1–7; pl. ii, figs. 1–4), reporting on the Terra Nova collection, first recognized *E. longirostris* larvae for what they were. Describing his specimens in my terms he found:

1 specimen of Furcilia, stage I
1 specimen of Furcilia, stage II
4 specimens of Furcilia, stage III
9 specimens of Furcilia, stage IV
4 specimens of Furcilia, stage V
1 specimen of Furcilia, stage VI
2 adolescents

He found in addition one larva (*op. cit.*, pl. i, fig. 1) with one pair of non-setose pleopods "so strikingly different from the later stages...that he hesitated for a long time before including it in the series". It is quite clear, now that the second and third

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[1] Since specimens of the previous stage were found of a length of 11·7 mm. it is probable that specimens of this stage are sometimes much bigger than any taken by me.

Calyptopis stages of *E. longirostris* are known, that this larva is of another species. It came from south of New Zealand. I found one exactly similar to it at a station south-west of Western Australia; and later stages of the same species—three specimens with one pair of setose and three pairs of non-setose pleopods, one specimen with four pairs of setose and one pair of non-setose pleopods—at a station south-west of the Cape. Both stations were in the warmer part of the sub-Antarctic zone; adult and larval *E. longirostris*, and large numbers of *E. similis* were taken at them. I suspect the unknown larvae to belong to the latter species. The order of the appearance of the pleopods appears to be the same as in *E. longirostris* and *E. spinifera*.

Illig (1930, pp. 504–7, figs. 183–190) described a series of later larvae from off the west coast of South Africa and south of the Cape, all, as the surface temperatures show, from the sub-tropical zone, as *E. longirostris*. I was convinced, because of the locality from which they came, that they were *E. spinifera*, and have examined a number of them (p. 294) and found them to be so.

The larval stages of *E. longirostris* and the numbers of each that I found are as follows:

CALYPTOPIS:	Second	9
	Third	20
FURCILIA:		
Stage I.	With 1 pair of non-setose pleopods	16
Stage II.	With 1 pair of setose, 3 pairs of non-setose pleopods	6
Stage III.	With 4 pairs of setose, 1 pair of non-setose pleopods	2
Stage IV.	With 5 pairs of setose pleopods, antennal endopod unsegmented	5
	With antennal endopod segmented, 6 terminal spines on telson	1
Stage V.	With antennal endopod segmented, 5 terminal spines on telson	2
	With antennal endopod segmented, 4 terminal spines on telson	3
Stage VI.	With antennal endopod segmented, 3 terminal spines on telson	5
Stage VII.	With antennal endopod segmented, 1 terminal spine on telson	1

These larvae were taken in the sub-Antarctic Zone south-west and south-east of the Cape and south-west of Western Australia.

Second Calyptopis (Fig. 39 *a*, *b*)

Description based on the examination of nine specimens, 2·0–2·1 mm. long.

The carapace seen from the side is dome-shaped and has a high and abrupt dorsal organ. Its lateral margins are sharply and deeply indented just behind the eyes and its anterior margin is emarginate in the centre, so that the carapace from above, disregarding its median posterior projection, has a cottage-loaf-like outline. The entire margin is beset with strong denticles. The median posterior projection is strong and usually curved upwards.

The antennular peduncle is of two or three segments with no spine. The antennae, mandibles, first and second maxillae and the first pair of thoracic limbs are present. The

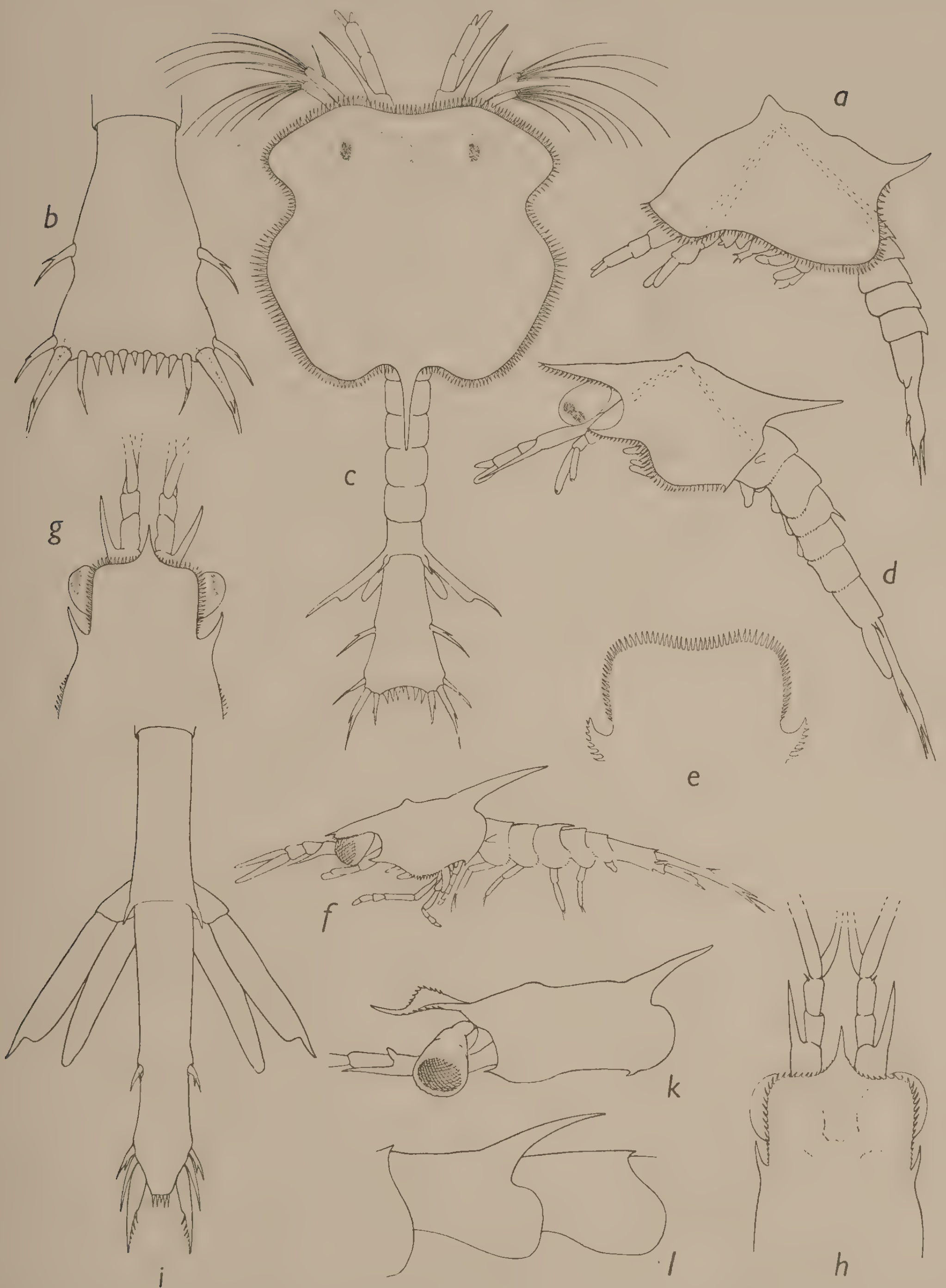

Fig. 39. *E. longirostris*. *a*, second Calyptopis from the side, × 33. *b*, second Calyptopis, telson from above, × 66. *c*, third Calyptopis from above, × 25. *d*, Furcilia, stage I from the side, × 16. *e*, Furcilia, stage I, frontal plate from above, × 16. *f*, Furcilia, stage III from the side, × 11. *g*, Furcilia, stage IV, front part of carapace and antennules, × 16. *h*, Furcilia, stage V, front part of carapace and antennules, × 23. *i*, Furcilia, stage V, telson from above, × 23. *k*, Furcilia, stage VII, carapace from the side, × 14. *l*, Furcilia, stage VII, third and fourth abdominal segments from the side, × 30.

thoracic segments without limbs are clearly visible as narrow encircling folds of the integument.

The abdomen is of six segments. The telson is short, wider distally than proximally; its margins between the lateral and postero-lateral spines are concave; the distal margin is emarginate with seven terminal spines, the innermost of which is much smaller than the others. Each of the postero-lateral spines has a secondary spine arising from it; the middlemost of the three pairs is much the longest (Fig. 39 *b*).

Third Calyptopis (Fig. 39 *c*)

Description based on the examination of ten specimens. Twenty were measured and were 3·3–3·6 mm. long.

The dorsal organ is high, abrupt and conical. The part of the carapace anterior to the constriction behind the eyes is larger in proportion to that behind than in the second Calyptopis. The entire margin of the carapace is closely set with strong denticles; the single pair of lateral denticles do not appear in this stage of this species as they do in each of the others described in this paper. The median posterior projection of the carapace is of much the same proportions as in the second Calyptopis.

The antennular peduncle is of three segments; the spine from the outer distal corner of the first is longer, or much longer, than the sum of the second and third. The flagella are represented by small single segments.

None of the second to eighth pairs of thoracic limbs is present as a free bud.

The abdomen is of seven segments. The hinder lower edges of the pleura are denticulate. The posterior lateral margins of the sixth somite are produced backwards to give a pair of short spines, one on either side of the telson as in the Furcilia stages of *E. triacantha*; they persist to the last Furcilia stage.

The telson is large, longer than the fourth to sixth somites, with its distal end expanded.

Furcilia, stage I (Fig. 39 *d*, *e*)

Description based on the close examination of ten specimens; sixteen were measured and were 4·2–4·7 mm. long.

In this stage there is one pair of non-setose pleopods.

The dorsal organ is a high cone rising abruptly from the carapace (Fig. 39 *d*). The frontal plate is very wide with an emarginate anterior margin and broadly rounded corners (Fig. 39 *e*). Its free edge is closely set with denticles, smaller on the lateral margins, stronger on the anterior. The margins of the carapace from the antero-lateral spines to the lateral denticles, which appear in this stage as short wide-based projections, are closely beset with denticles. There are no denticles along the margins of the concavities between the antero-lateral spines and the base of the frontal plate, and none posterior to the lateral denticles. The median posterior projection usually reaches as far back as the end of the second abdominal segment, but in one of the specimens it was very short and thick.

The antennular spine is longer than the sum of the second and third peduncular segments; the flagella are represented by single segments.

Of the second to eighth thoracic limbs the second only may be free as large simple buds; or the second and third may be free, the second large and beginning to bud off exopod and gill, the third small and simple.

A pair of narrow lateral protuberances stand strongly out from the tergum of the first abdominal somite, their ends curved downwards and forwards: they are the beginnings of the "tergal wings". The hinder lower edges of the pleura of the abdominal somites are denticulate. There is a median posterior spine on the third abdominal somite, a quarter to half as long as the fourth somite. The telson is very similar to that of the third Calyptopis.

Furcilia, stage II

Description based on the examination of six specimens, 5·0–5·4 mm. long.

In this stage there is one pair of setose and three pairs of non-setose pleopods.

The dorsal organ is a high and abrupt cone. The frontal plate is narrower than that of Furcilia stage I, but in five of the specimens it is otherwise similar to it; in the sixth specimen there is a small spine, the beginning of the rostrum, shorter than the denticles on either side of it, in the centre of the anterior margin. The lateral margins of the carapace may, as in the previous stage, be denticulate from the antero-lateral spines to the lateral denticles, the more anterior denticulations being very small or absent. The posterior projection of the carapace is strong and of great length; it may be as long as, or longer than, the first three abdominal somites.

The antennular spine is longer than the sum of the second and third segments of the peduncle; the flagella are still unsegmented.

The degree of development of the thoracic limbs is as follows:

Second limb. Endopod of five segments and feebly kneed. A gill bud of two branches.

Third limb. Short, bifurcate and setose but not segmented, a single gill bud; or endopod of three or four segments and gill bud budding off a second branch.

Fourth limb. Free bud.

Posterior limbs. Not free.

The tergal wings of the first abdominal somite are stronger than in the previous stage and bent farther forward distally. The hinder lower edges of the pleura of the abdominal somites are denticulate. The spine of the third somite is stout and about half the length of the fourth. The telson is similar to those of the two previous stages.

Furcilia, stage III (Fig. 39*f*)

Description based on the examination of two specimens, 6·0 and 6·3 mm. long.

In this stage there are four pairs of setose and one pair of non-setose pleopods.

The dorsal organ is high and abrupt. The frontal plate is square, its lateral margins nearly parallel, its corners squarely rounded; the anterior margin is weakly emarginate with a small projection, the rostral spine, arising from its centre; the anterior and the lateral margins are strongly denticulate. The lateral margins of the carapace remain denticulate for a part of their length, from some way posterior to the antero-lateral spines to some way anterior to the lateral denticles. The posterior projection of the carapace is very strong and wide-based in both specimens; in one it reaches to the end of the second, in the other to near the end of the third, abdominal somite.

The antennular spine is longer, the flagella considerably longer, than the sum of the second and third segments of the peduncle. The flagella are not yet distinctly segmented.

The thoracic limbs of the larger specimen are as follows:

First limb. Endopod short, of same length as exopod.

Second limb. Endopod of five segments and kneed. Gill of two unequal branches.

Third limb. Endopod shorter than second and feebly kneed. Gill of two unequal branches.

Fourth limb. Endopod much shorter than third, of five segments but not kneed. Gill of two unequal branches.

Fifth limb. Very short, bifurcating, non-setose, with a single gill bud.

Sixth limb. A small undifferentiated bud.

Seventh limb. A small gill bud of two unequal branches.

Eighth limb. A small undifferentiated bud.

The hinder lower edges of the pleura of the abdominal somites are very finely denticulate. The spine of the third segment is about half the length of the fourth. The distal end of the telson is narrower than in the previous stage. The middlemost of the postero-lateral spines is still the longest, the innermost is greatly thickened at the base.

Furcilia, stage IV (Fig. 39 *g*)

Description based on the examination of five specimens, 6·5–6·9 mm. long.

In this stage the antennal endopod is unsegmented and there are five pairs of setose pleopods.

The dorsal organ is high and abrupt. The frontal plate is wide and square with its corners rounded and its margins beset with denticles; the centre of its anterior margin is produced into a strong rostral spine with a wide base which reaches as far as halfway along, or nearly to the end of, the second segment of the antennular peduncle. The same portions of the lateral margins of the carapace are denticulate as in the previous stage (Fig. 39 *g*). The posterior projection of the carapace is strong and reaches as far as the end of the second, or halfway down the third, abdominal somite.

The antennular spine is as long as or longer than the sum of the second and third segments of the peduncle. The flagella are long and segmented.

The thoracic limbs of a specimen 6·5 mm. long are as follows:

First limb. Endopod longer than exopod but still of two segments.
Second and third limbs. Endopods long and kneed. Gills of two branches.
Fourth limb. Endopod shorter but kneed. Gill of two branches.
Fifth limb. Endopod short, of three segments. Gill of two branches.
Sixth limb. A low bud, not bifurcating but budding off a gill.
Seventh limb. A gill of two branches.
Eighth limb. A small undifferentiated bud.

There are no denticulations along the edges of the pleura of the abdominal somites. The tergal wings of the first somite are very strong. The spine of the third is about three-quarters the length of the fourth somite. The posterior margin of the telson is narrow and straight with seven terminal spines. The innermost of the postero-lateral spines is now the longest; it has a thick base, and where it narrows distally on the inner margin there is a row of strong spines.

Furcilia, stage V (Fig. 39 *h*, *i*)

Description based on the examination of six specimens, 7·0–7·7 mm. long.

I have regarded the six specimens with six, five or four spines on the telson (see list on p. 286) as belonging to one group, and the description given below is based upon them. Their antennal endopods are segmented and they appear to be at roughly the same stage of development. Their lengths are as follows:

With six terminal spines: 1 specimen, 7·0 mm.
With five terminal spines: 2 specimens, both 7·5 mm.
With four terminal spines: 3 specimens, 7·0, 7·4 and 7·7 mm.

I have little doubt, by analogy with the other species described here, that if large numbers of this stage were taken the majority would be found to have five terminal spines on the telson.

The dorsal organ is prominent. The frontal plate is as in the previous stage, but the rostral spine is longer, reaching nearly to the end or to the end of the second segment of the antennular peduncle. There are no denticulations along the lateral margins of the carapace (Fig. 39 *h*). The posterior projection of the carapace reaches from more than halfway down, to beyond the end of, the second abdominal somite.

The antennular spine is as long as the sum of the second and third peduncular segments; the lappet of the first segment is not developed. The mandibular palp is small and unsegmented.

The thoracic limbs of a specimen 7·5 mm. long are as follows:

First limb. Endopod of five segments and over twice as long as exopod.
Second limb. Endopod long and kneed. Gill of two larger and one smaller branch.
Third limb. Endopod long and kneed. Gill of two large and one very small branch.
Fourth limb. Endopod shorter but kneed. Gill as in third limb.

Fifth limb. Endopod of five segments and not kneed. Gill of two equal branches.

Sixth limb. Very short, bifurcating, non-setose. Gill budding off a second branch.

Seventh limb. A gill of two large and two small branches.

Eighth limb. A very small gill bud, single or branching.

The spine from the third abdominal somite varies from being over half the length of the fourth somite to being, more frequently, as long as it. The innermost pair of postero-lateral spines are thicker and longer than in the previous stage; each has a row of strong spines along the distal half of the inner margin (Fig. 39 *i*).

Furcilia, stage VI

Description based on the examination of four specimens, 7·7–8·3 mm. long.

In this stage there are three terminal spines on the telson.

In three specimens the dorsal organ is high and abrupt, in one a low crest. The frontal plate and rostral spine are similar to those of the previous stage except that in one specimen the rostral spine is very short; it appears malformed. The posterior projection of the carapace varies from reaching nearly to the end of, to reaching less than halfway down, the second abdominal somite.

The antennular spine is as long as, or shorter than, the sum of the second and third segments of the peduncle. The beginnings of the lappet of the first segment and of the carina of the third may be present. The mandibular palp is unsegmented and non-setose in one of the specimens, 7·9 mm. long, but of three segments and setose in the other three, 8·0, 8·2 and 8·3 mm. long.

The thoracic limbs of a specimen 8·3 mm. long are as follows:

First limb. Endopod considerably longer than to knee of second, weakly kneed. No gill bud.

Second and third limbs. Gills of three roughly equal branches.

Fourth limb. Endopod long and kneed. Gill of three roughly equal branches.

Fifth limb. Endopod long and kneed. Gill of three branches, two large and one small.

Sixth limb. Endopod short, of five segments and weakly kneed. Gill of three equal branches and a number of small buds.

Seventh limb. Gill of four branches and a number of small buds.

Eighth limb. Gill of two small and three smaller branches.

The tergal wings of the first abdominal somite are changing their shape to approach that of the adult; the free edge has a well-defined angle dorso-anteriorly, a poorly defined angle ventrally. The spine of the third somite is nearly as long, or as long, as the fourth somite. The telson is narrower than in the previous stage; an additional pair of lateral spines has appeared between the pair present in earlier stages and the postero-lateral spines. The middlemost pair of the latter is becoming reduced.

Furcilia, stage VII (Fig. 39 *k, l*)

Only one specimen was found, 8·5 mm. long.

In this stage there is one terminal spine on the telson.

The dorsal organ is a low crest. The frontal plate and rostral spine are much as in the previous stage; the posterior projection of the carapace is shorter, reaching only to the end of the first abdominal somite.

The antennular spine reaches some way up the third segment of the peduncle; beginnings of the lappet of the first segment and of the carina of the third are present. The mandibular palp is long, of three segments and setose.

The thoracic limbs are as follows:

First limb. Endopod long and kneed. No gill bud.

Second to fifth limbs. Endopods long and kneed. Gills of three branches.

Sixth limb. Endopod very much shorter than that of the anterior limbs but kneed. A gill of three branches.

Seventh limb. A gill of four branches and a number of small buds.

Eighth limb. A gill of two small branches and smaller buds.

The third abdominal somite is still the only one to have a median posterior spine; it is shorter than the fourth segment (Fig. 39 *l*). The pair of postero-lateral spines of the sixth segment which appeared in the third Calyptopis stage are still present though very short. The telson is very narrow; there are three pairs of lateral spines along its distal half.

Post-Larval Stages

Twenty-six specimens were found of which ten were closely, and sixteen more superficially, examined.

(i) *With carapace retaining a long posterior projection.*

The posterior projection of the carapace is longer in all the larval stages of this species than in the corresponding stages of *E. spinifera*, and the earliest post-larval stages, unlike those of *E. spinifera*, retain it. Three specimens were found, 9·7, 10 and 11 mm. long.

The frontal plate is reduced compared with that of the later Furcilia stages, but its lateral margins are still nearly parallel at the base; anteriorly they run obliquely forwards to the rostral spine giving the front half of the plate a triangular shape. The margins are denticulate. The rostral spine reaches from nearly to the end, to beyond the end, of the second segment of the antennular peduncle. The posterior projection of the carapace is as long as or longer than the first abdominal somite.

The antennular spine reaches halfway or nearly halfway up the third segment of the peduncle; the lappet of the first segment is strong but not yet bifid; there is no spine from near the outer distal corner of the second segment; the dorsal carina of the third is beginning to develop.

The spine of the third abdominal somite is nearly as long as the fourth; very small spines are present on the fourth and fifth somites. The postero-lateral spines of the sixth are still present.

(ii) *With carapace having no posterior projection or, rarely, with a short stump remaining.*

Twenty-three specimens were found of which seven were closely examined. Their lengths are: three of 11·5 mm., two of 12·0 mm., and one each of 12·5 and 13·0 mm.

Of the twenty-three two of the smaller, 11·5 and 12·0 mm. long, retain short blunt stumps of the posterior projection of the carapace.

In the younger the lateral margins of the frontal plate are roughly parallel for only a short distance at the base, beyond which they turn by rounded angles obliquely inwards to make the distal part of the plate triangular. In the older the angles become at first sharp, and then a forwardly directed spine arises from each, forerunners of the post-ocular spines of the adult. The margins from the corners, or spines, to the base of the rostrum are still denticulate. The rostrum most frequently reaches nearly to the end, sometimes to or even beyond the end, of the second peduncular segment of the antennule.

The antennular spine is as long as or much shorter than the second segment of the peduncle; the lappet of the first segment is large and erect, and it is bifid in all but two of the specimens, both of them 11·5 mm. long; there may or may not be a small spine near the outer distal corner of the second segment.

The postero-lateral spines of the sixth abdominal somite may or may not be present. The telson may have one to four pairs of lateral spines.

The sixteen specimens examined more superficially range in size from 12 to 15 mm. Even in the largest of them the margins of the frontal plate are denticulate.

DEVELOPMENT OF **Euphausia spinifera**

Zimmer (1914, p. 429) recognized what he described as larval stages of *E. spinifera*, compared the younger with the older and showed that the former were the same as *Euphausia schotti*, Ortmann (Ortmann, 1893, p. 13, pl. vii, figs. 8, 8*a*). Tattersall (1924, p. 26) recognized two Furcilia stages and a post-larval stage and compared them with those of *E. longirostris*. As already mentioned on p. 286 Illig (1930, pp. 504–7, text-figs. 183–190) described as *E. longirostris* a number of larvae which I was convinced must be *E. spinifera* because they were all from the sub-tropical zone, from stations where the surface temperatures varied from 15·9 to 17·1° C. I am indebted to Prof. A. Schellenberg of the Zoologisches Museum, Berlin, for the opportunity to examine some of Illig's material. I saw those specimens from St. 90 described by Illig as ten females and seven larvae, 10–4 mm. long. They are undoubtedly the following stages of *E. spinifera*:

Furcilia, stage III: 2 specimens.
Furcilia, stage IV: 2 specimens.
Furcilia, stage V: 1 specimen.
Furcilia, stage VI: 1 specimen (and almost certainly a second with a damaged telson).
Post-larval stages, 9 specimens.

Illig described and figured stages IV–VI as well as stage VII which was not present at St. 90, but not stage III. One of the post-larval forms from St. 90 was smaller than, and differed in other ways from, any I had seen (p. 302).

The larval stages and the number of each that I found are as follows:

Calyptopis:	Second	1
	Third	5
Furcilia:		
Stage I.	With 1 pair of non-setose pleopods	11
	With 1 pair of setose, 2 pairs of non-setose pleopods	1
Stage II.	With 1 pair of setose, 3 pairs of non-setose pleopods	2
Stage III.	With 4 pairs of setose, 1 pair of non-setose pleopods	3
Stage IV.	With 5 pairs of setose pleopods, antennal endopod unsegmented	6
Stage V.	With antennal endopod segmented, 5 terminal spines on telson	3
Stage VI.	With antennal endopod segmented, 3 terminal spines on telson	5
Stage VII.	With antennal endopod segmented, 1 terminal spine on telson	9

Second Calyptopis (Fig. 40 *a*)

Only one specimen was found, 1·9 mm. long.

The carapace is expanded over each eye. The anterior margin is emarginate between the expansions; the lateral margins are constricted where the expansions end behind the eyes. The margin of the carapace anterior to these constrictions is denticulate. There is a very abrupt and high dorsal organ, conical in shape, and a median posterior projection.

The antennular peduncle is of three indistinct segments. The antennae, mandibles, first and second maxillae and the first pair of thoracic limbs are present as in this stage of other species.

The abdomen is of six segments. The telson is slightly expanded distally; it has seven terminal spines of which the innermost is the smallest and three pairs of postero-lateral spines of which the middlemost is the longest.

Third Calyptopis (Fig. 40 *b*)

Description based on the examination of four specimens, 3·0–3·3 mm. long.

The dorsal organ is conical, abrupt and high. The carapace is constricted behind the eyes and broader in front, where there is a wide and rounded expansion over each eye, than behind. Between the expansions the anterior margin is emarginate. The margin of the front part of the carapace, anterior to the constriction behind the eyes, is beset with strong denticles, those on the lateral margin directed slightly forwards, those on the anterior slightly inwards. There is a pair of lateral denticles and a strong median posterior projection.

The antennular peduncle is of three segments, the spine of the first longer than the sum of the second and third.

The second to eighth thoracic segments are visible as narrow encircling folds of the integument; on none of them are the buds of the limbs free.

The abdomen is of seven segments, longer than the carapace. The posterior lateral margins of the sixth somite are produced backwards into a pair of short spines; as in *E. triacantha* and *E. longirostris* these spines persist throughout the later Furcilia stages but disappear before the adult form is reached. The telson is longer than the fourth to sixth segments of the abdomen and strongly expanded distally. Its posterior margin is emarginate; the spines are as in the second Calyptopis.

A fifth third Calyptopis occurred which I believe to be *E. spinifera* despite the strong differences between it and those described above (Fig. 40 *c*). It is much smaller than they are, only 2·5 mm. long, and differed from them in that (i) the dorsal organ is small, (ii) the front part of the carapace is much narrower than the posterior and not expanded widely over each eye, so that the narrow anterior margin is only faintly emarginate.

I separate this specimen from the other four with greater confidence than these differences would give me because what appear to be two corresponding kinds of the first Furcilia stage occur (see below). It occurred in a net haul which included one of the four specimens of the third Calyptopis described above, one of each of the two kinds of the first Furcilia stage described below, later Furcilia stages and adults, of *E. spinifera*.

Furcilia, stage I (Fig. 40 *d*)

Description based on the examination of seven specimens, 4·0–4·2 mm. long.

In this stage there is one pair of non-setose pleopods.

The carapace has a high conical dorsal organ. The frontal plate is wide with broadly rounded corners and an emarginate anterior margin; the entire margin is beset with denticles, the lateral pointing slightly forwards, the anterior inwards. The only part of the lateral margin of the carapace which is denticulate is that along and immediately posterior to the antero-lateral spines. The posterior limit of the denticles is the point where the carapace broadens out into a postero-lateral wing, a point which corresponds with the constriction in the carapace in the third Calyptopis. The posterior projection of the carapace is longer than in the previous stage.

The antennular spine is longer than the sum of the second and third peduncular segments; it is wide with a small number of strong spines along its inner margin (omitted from the figure). The flagella are unsegmented.

Buds of the second thoracic limbs only are free; they are large.

Beginnings of the tergal wings of the first abdominal somite are present, standing strongly out with their distal ends curved forwards and downwards. There is a small median posterior spine on the third somite but not on the fourth or fifth. The hinder lower edges of the pleura are not denticulate. The telson is similar to that of the previous stage.

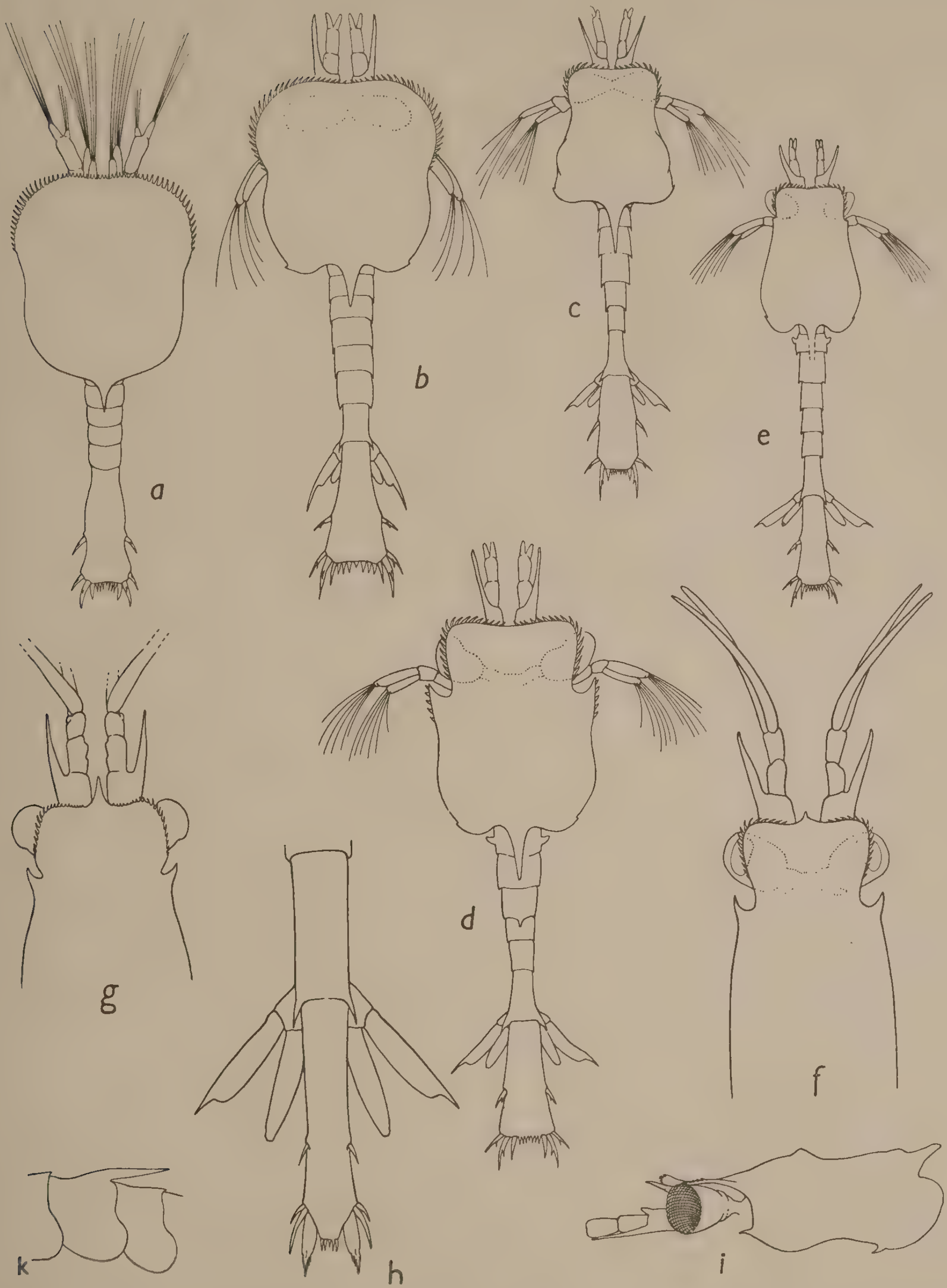

Fig. 40. *E. spinifera*. *a*, second Calyptopis, × 38. *b*, third Calyptopis, × 22. *c*, third Calyptopis, small kind, × 22. *d*, Furcilia, stage I, × 18. *e*, Furcilia, stage I, small kind, × 18. *f*, Furcilia, stage IV, front part of carapace and antennules from above, × 22. *g*, Furcilia, stage V, front part of carapace and antennules from above, × 16. *h*, Furcilia, stage V, telson, from above, × 26. *i*, Furcilia, stage VI, carapace and antennule from the side, × 14. *k*, Furcilia, stage VI, third and fourth abdominal segments from the side, × 14.

Four other first Furcilia occurred which I believe to be *E. spinifera* (Fig. 40 *e*). They differ from those described above in the following ways:

(i) They are smaller: 3·0, 3·1, 3·3 and 3·5 mm. long.

(ii) The dorsal organ is inconspicuous or absent.

(iii) The frontal plate is proportionately smaller and narrower than the carapace and its anterior margin is nearly straight.

(iv) There are no denticulations on the lateral margins of the carapace by the antero-lateral spines.

(v) There is no spine on the third abdominal somite.

They occurred in three separate net hauls which contained, as well, other larval stages and adults of *E. spinifera*. They are certainly the same species as the third Calyptopis (Fig. 40 *c*) described from one specimen at the end of the last section: the frontal plate is very similar. If they are *E. spinifera* then there are in that species two kinds of the third Calyptopis and of the first Furcilia stage, the larger kind of one stage corresponding in structure with the larger of the other, the smaller with the smaller. I have not found two corresponding kinds of larvae in the succeeding stages, but the numbers of specimens found and examined were very small.

Furcilia, stage II

Description based on two specimens, 5·0 and 5·1 mm. long.

In this stage there are one pair of setose and three pairs of non-setose pleopods.

The dorsal organ is very high. The frontal plate is not so expanded over the eyes as in the first Furcilia: it is narrower and its lateral margins are nearly parallel. It has rounded corners, is emarginate anteriorly, and is denticulate as in the previous stage. A few denticles occur on the lateral margins of the carapace by the antero-lateral spines. The carapace has a long and strong posterior projection.

The antennular spine is as long as the sum of the second and third peduncular segments; the flagella are unsegmented.

The degree of development of the thoracic limbs is as follows:

Second limb. Endopod of five segments and setose. A strong gill bud which may be branched.

Third limb. Bifurcating, non-setose, with a strong gill bud which may be branching.

Fourth limb. A free simple bud.

The tergal wings are developed further, the spine of the third abdominal somite is stronger, than in the previous stage. The telson is the same as in the third Calyptopis and the first Furcilia.

Furcilia, stage III

Description based on three specimens, 5·7, 5·8 and *ca.* 6·5 mm. long.

In this stage there are four pairs of setose and one pair of non-setose pleopods.

In one the dorsal organ is strong but not very high; in the other two it is low. The frontal plate is different in each of the three specimens: in one it is as in the previous stage; in another it is similar except that the anterior margin is nearly straight; in the third it is square with its anterior margin almost straight and with a tiny spine in the centre—the beginning of the rostrum.[1]

In one there are a few denticles on the lateral margin of the carapace by the antero-lateral spines, but in the other two there are none. The posterior projection of the carapace is strong, as long as the first and second abdominal somites.

The antennular spine is as long as the sum of the second and third peduncular segments; the flagella are of the same length and beginning to segment.

The thoracic limbs of the specimen *ca.* 6·5 mm. long are as follows:

Second limb. Endopod of five segments and feebly kneed. A gill of two branches.

Third limb. Endopod much shorter than that of second, of five segments and feebly kneed. A gill of two branches.

Fourth limb. Short, the endopod of three indistinct segments, setose. A gill of two branches.

Fifth limb. A small bud about to bifurcate and to bud off a gill.

Sixth limb. No free bud.

Seventh limb. A single gill bud.

Eighth limb. No free bud.

The spine of the third abdominal somite is very strong, half or more than half as long as the fourth somite. The posterior margin of the telson carrying the seven terminal spines is considerably narrower than in the previous stage. The middlemost of the three postero-lateral spines is still the longest; the innermost is thickening or very thick.

Furcilia, stage IV (Fig. 40 *f*)

Description based on the examination of six specimens. One is 6·0, two are 6·4, and one each 6·5, 6·7 and 6·8 mm. long.

In this stage there are five pairs of setose pleopods and an unsegmented antennal endopod.

The dorsal organ may be conspicuous but not high, or a low crest. In one specimen the frontal plate is large and square with rounded corners, nearly parallel lateral margins, an emarginate anterior margin and its edges beset with denticles, but with no beginning of the rostral spine. In the other five it is as above except (i) that in two it is wider at the end than at the base so that the lateral margins are not parallel, (ii) that the anterior margin is only feebly emarginate or nearly straight and has at its centre a spine, the beginning of the rostral spine, standing well out beyond the denticles. In five of the specimens the posterior projection of the carapace reaches halfway or more down the second abdominal somite; in the sixth it is only half the length of the first somite.

The antennular spine may be longer or shorter than the sum of the second and third peduncular segments. The flagella are long and segmented.

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[1] Note that although this spine may be present in this stage it may be absent in the next.

The thoracic limbs of two specimens, (*a*) 6·0 mm., (*b*) 6·7 mm. long, were examined. Their degree of development is as follows:

First limb. *a* and *b*. Endopod of two segments, longer than exopod. No gill bud.

Second and third limbs. *a*. Endopod long and kneed. A gill of two branches. *b*. Endopod long and kneed. A gill of two equal and a third smaller branch.

Fourth limb. *a*. Endopod considerably shorter than third, kneed. A gill of two branches. *b*. Endopod long but not kneed. Gill as in second.

Fifth limb. *a*. A short bifurcate bud, the endopod setose but not segmented. A gill of two branches. *b*. Endopod short but of five segments. A gill of two branches.

Sixth limb. *a*. A very low bud. *b*. Bifurcate, non-setose. Gill of three unequal branches.

Seventh limb. *a*. A gill of two branches. *b*. A gill of two larger and two smaller branches.

Eighth limb. *a*. A very low bud. *b*. A small single gill bud.

The spine of the third abdominal somite is very strong, nearly as long as the fourth somite. The posterior margin of the telson is narrower than in the previous stage, but it still carries seven spines. The middlemost of the postero-lateral spines is still the longest; the innermost is greatly thickened with a group of spines on the inner margin where it narrows distally.

Furcilia, stage V (Fig. 40 *g*, *h*)

Description based on the examination of three specimens, 7·4–7·5 mm. long.

In this stage the antennal endopod is segmented and there are five terminal spines on the telson.

The dorsal organ is conspicuous but not very high. The frontal plate is not reduced compared with that of the previous stage: it is still wide and square with denticulate margins. But the rostral spine is much bigger, reaching nearly as far forward as the end of the first segment of the antennular peduncle. The posterior projection of the carapace reaches a half or a third way down the second abdominal somite.

The antennular spine may be as long as the sum of the second and third peduncular segments.

The mandibular palp is small and unsegmented.

The thoracic limbs of a specimen 7·4 mm. long are as follows:

First limb. Endopod of five segments, not kneed, shorter than to knee of second. No gill bud.

Second to fourth limbs. Endopods long and kneed. Gills of one large and two small branches.

Fifth limb. Endopod shorter but kneed. Gill as in second to fourth.

Sixth limb. Bifurcate, endopod of two segments, setose. Gill of three branches.

Seventh limb. Gill of three large and other smaller branches.

Eighth limb. Gill of two small and other smaller branches.

The spine from the third abdominal somite is as long as or longer than the fourth somite. The telson is narrower than in the previous stage; it still has, as in earlier stages, only one pair of lateral spines. The innermost of the three pairs of postero-lateral spines is very strong and long—now the longest of the three (Fig. 40 *h*).

Furcilia, stage VI (Fig. 40 *i*, *k*)

Description based on the examination of five specimens, 7·5–8·2 mm. long.

In this stage there are three terminal spines on the telson.

The dorsal organ may be high or it may be a low crest. The frontal plate is square with rounded corners and a denticulate margin, a little reduced compared with that of the previous stage; the rostral spine is stronger and longer but reaches only to the end of the first segment of the antennular peduncle. In three of the specimens the posterior projection of the carapace reaches beyond the end of the first abdominal somite; in one it is shorter; in the fifth it is but a short stump reaching no farther posteriorly than the postero-lateral wings of the carapace (Fig. 40 *i*).[1]

The antennular spine may still reach as far as the end of the third segment of the peduncle. The first segment may have a small simple lappet and the third the beginnings of a carina.

The mandibular palp is unsegmented and non-setose in four specimens, but it is indistinctly segmented and setose in the fifth.

The thoracic limbs of the specimen 7·5 mm. long are as follows:

First limb. Endopod of five segments, as long as to knee of second, feebly kneed. No gill bud.

Second to fifth limbs. Endopods long and kneed. Gills of three branches.

Sixth limb. Very short. Endopod of three segments. Gill of three branches.

Seventh limb. A gill of four large branches.

Eighth limb. A gill of two small branches.

The tergal wings of the first abdominal somite may be simple in shape as in previous stages or they may be becoming rectangular. The spine of the third somite is as long as or longer than the fourth somite (Fig. 40 *k*). The telson is narrow with one or two pairs of lateral spines.

Furcilia, stage VII

Description based on the examination of nine specimens. One was 7·8 mm. long and two each were 8·5, 8·6, 8·7 and 9·0 mm. long.

In this stage there is one terminal spine on the telson.

The dorsal organ is high in all the specimens (compare with the previous stage). The frontal plate may be somewhat reduced, but it is still square with rounded corners and strongly denticulate margins. The rostral spine is much stronger, rising with a wide triangular base from the frontal plate and reaching in all but two specimens to halfway up the second segment of the antennular peduncle; in one specimen it is much shorter, in the other completely wanting. A strong crest runs from the dorsal organ to the base of the rostral spine. The carapace has no posterior projection or, at most, a low blunt projection shorter than the postero-lateral wings.

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[1] Compare with the next stage: the reduction of this projection appears to be rapid.

The antennular spine may still be as long as the sum of the second and third segments of the peduncle. The lappet of the basal segment is usually large and simple, its margin not incised; the beginnings of the carina of the third segment may be present.

In some of the specimens the mandibular palp is unsegmented and non-setose; in most it is of three segments and setose.

The thoracic limbs of one of the specimens, 8·6 mm. long, are as follows:

First limb. Endopod long and kneed. A very small gill bud.

Second and third limbs. Endopods long and kneed. Gills of three roughly equal branches.

Fourth and fifth limbs. Endopods long and kneed. Gills of two large and one smaller branch.

Sixth limb. Endopod shorter, of five segments but not kneed. Gill of three large branches and small buds of others.

Seventh limb. A gill of four large branches and small buds.

Eighth limb. A gill of four medium-sized branches and one small bud.

The tergal wings of the first abdominal somite are becoming rectangular. The spine of the third somite is very strong, longer or appreciably longer than the fourth somite. There are as yet no spines on the fourth and fifth somites. The postero-lateral spines of the sixth somite are still present but very short. The telson is narrow with one to three pairs of lateral spines. Of the postero-lateral spines those of the innermost pair are strong and wide, the middlemost are reduced, the outer very small.

Post-Larval Stages

In none of the specimens I have examined, nine from the present collection and nine from the material described by Illig (see p. 294), is there any trace of the posterior projection of the carapace.[1] It is retained by the earliest post-larval stages of *E. longirostris*.

The nine specimens of this collection are of the following lengths:

9·5 mm.	1	10·6 mm.	1
10·0 ,, ...	2	11·0 ,, ...	1
10·2 ,, ...	1	11·2 ,, ...	1
10·5 ,, ...	1	13·0 ,, ...	1

Tattersall's single specimen was only 8·5 mm. long (Tattersall, 1924, p. 26). I found one even smaller among Illig's material: it was only a little over 7 mm. and had a wide frontal plate with rounded antero-lateral corners and no trace of a rostral spine. This must be an abnormal specimen, for the rostral spine is usually strong in the last three Furcilia stages.

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[1] Tattersall (1924, p. 26) says that his post-larval specimen "agrees closely with Ortmann's description and figure of *E. schotti*" (Ortmann, 1893, pl. vii, fig. 8). But Ortmann's figure shows a strong posterior projection on the carapace whereas Tattersall's post-larva, which I have been able to examine in the Natural History Museum, has none. Ortmann's figure appears to be of a late, but not the last, Furcilia.

The shortest specimen of the present collection, 9·5 mm., differs from the others in the following ways: (i) the frontal plate is square as in the last Furcilia; (ii) the antennular spine reaches more than halfway along the third segment of the peduncle; (iii) the antennular lappet is simple with a rounded margin; (iv) there is no spine from the outer distal corner of the second segment of the peduncle. The telson has two pairs of lateral spines. Otherwise it resembles the seven specimens described below.

In the seven larger specimens, 10·0–11·2 mm. long, the frontal plate is no longer of the square larval form. For a short distance at the base of the plate the lateral margins are roughly parallel; beyond that they bend obliquely inwards—to make the distal part of the plate triangular—by corners which are gently rounded in the five smaller specimens, but sharply angular in the larger two. It is from these corners that the post-ocular spines arise as in *E. longirostris*. The margins of the frontal plate from the corners to the base of the rostrum are denticulate. The rostrum reaches halfway, or more often more than halfway, along the second peduncular segment of the antennule.

The antennular spine varies from being as long to being half as long as the second peduncular segment. The lappet is wide upstanding and incised, with two, three or more points. There is a spine from the upper outer distal corner of the second segment of the peduncle. The hepatic spines of the carapace are not present, but the projections described in the largest specimen (below) can be seen to be developing.

The free anterior margins of the tergal wings of the first abdominal somite may be concave as in the adult. The third abdominal spine is as long as or longer than the fourth somite; very small spines are present on the fourth and fifth somites. The postero-lateral spines of the sixth somite are present in some, absent as in the adult from others. The telson has two to four pairs of lateral spines.

In the largest specimen, 13 mm. long, the margins of the frontal plate are not denticulate; the post-ocular spines are present at its basal angles. The rostrum reaches far along the second peduncular segment of the antennule.

The lappet of the first, and the dorsal carina of the third, segment of the antennular peduncle appear fully formed.

The hepatic spines of the carapace are not yet formed, but there is on either side of the carapace a large projection which is rounded off on all sides but the anterior where there is a vertical face; from that the hepatic spine will arise (see Fig. 19 *a*, p. 225).

The free anterior margins of the tergal wings of the first abdominal somite are concave as in the adult. The third abdominal spine is nearly as long as the fourth somite; the fourth and fifth are very small. The sixth somite has no postero-lateral spines. There are four pairs of lateral spines on the telson.

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APPENDIX I

Table showing the positions at which the species of Euphausia *occurred.*

Almost all the hauls were made with the 1 m. net, towed obliquely between the depths indicated; but in surface hauls (0–5 m.) the net was towed horizontally. A few hauls made with the 70 cm. net are marked with an asterisk (*); while those which were examined only for *E. superba* are marked with a dagger (†).

Station	Date	Position	Surface temperature, ° C.	Depth of net, m.	*E. lucens*	*E. vallentini*	*E. frigida*	*E. superba*	*E. spinifera*	*E. longirostris*	*E. triacantha*	*E. similis*	*E. similis* var. *armata*
721	1931 13. xi	53° 58′ S, 61° 59′ W	—	125–0	—	×	—	—	—	—	—	—	—
				250–144	×	×	—	—	—	—	—	—	—
722	14. xi	53° 56′ S, 64° 14′ W	5·64	90–0	—	×	—	—	—	—	—	—	—
725	16. xi	53° 27′ S, 75° 59′ W	6·84	150–0	—	×	—	—	—	—	—	—	—
				250–196	—	×	—	—	—	—	×	—	—
726	18. xi	55° 05′ S, 75° 00′ W	7·01	108–0	—	×	—	—	—	—	—	—	—
727	18. xi	56° 13′ S, 75° 07′ W	5·91	124–0	—	×	—	—	—	—	×	—	—
				310–170	—	×	—	—	—	—	—	—	—
729	19. xi	58° 27′ S, 75° 07′ W	4·61	102–0	—	×	×	—	—	×	×	×	—
				256–194	—	—	—	—	—	—	—	×	—
731	20. xi	60° 36′ S, 75° 04′ W	1·81	62–0	—	—	×	—	—	—	×	—	—
				246–170	—	—	×	—	—	—	×	—	—
733	21. xi	62° 57′ S, 75° 02′ W	1·07	84–0	—	—	×	—	—	—	—	—	—
				300–140	—	—	×	—	—	—	×	—	—
735	22. xi	63° 55′ S, 73° 29′ W	−1·39	62–0	—	—	—	×	—	—	—	—	—
				216–168	—	—	×	—	—	—	×	—	—
737	24. xi	62° 47′ S, 69° 25′ W	−1·12	109–0	—	—	×	×	—	—	—	—	—
				166–90	—	—	×	—	—	—	×	—	—
739	24. xi	61° 26′ S, 64° 32′ W	−1·31	121–0	—	—	×	×	—	—	—	—	—
				172–85	—	—	×	×	—	—	×	—	—
741	25. xi	59° 54′ S, 61° 03′ W	−0·53	123–0	—	—	×	—	—	—	—	—	—
				286–126	—	—	×	—	—	—	×	—	—
743	26. xi	59° 23′ S, 55° 54′ W	−0·42	149–0	—	—	×	×	—	—	—	—	—
				264–108	—	—	×	×	—	—	×	—	—
746	28. xi	56° 21′ S, 55° 50′ W	3·41	125–0	—	—	×	—	—	—	—	—	—
				306–124	—	—	—	—	—	—	×	—	—
748	29. xi	55° 29′ S, 54° 14′ W	4·38	180–0	—	×	×	—	—	—	×	—	—
				204–138	—	—	—	—	—	—	×	—	—
750	30. xi	53° 05′ S, 54° 05′ W	4·73	97–0	—	×	×	—	—	—	×	—	—
				280–130	—	×	×	—	—	×	×	—	—
751	1. xii	51° 29′ S, 49° 18′ W	2·60	104–0	—	—	×	×	—	—	×	—	—
				269–138	—	—	×	×	—	—	×	—	—
753	2. xii	52° 02′ S, 49° 12′ W	2·59	165–0	—	×	—	—	—	×	×	—	—
				280–110	—	×	×	—	—	×	×	×	—
755	3. xii	55° 58′ S, 48° 59′ W	0·80	130–0	—	—	×	—	—	—	×	—	—
				210–130	—	—	×	×	—	—	×	—	—
757	5. xii	58° 03′ S, 48° 50′ W	0·18	156–0	—	—	×	×	—	—	×	—	—
				320–136	—	—	×	×	—	—	×	—	—
759	5. xii	59° 06′ S, 48° 40′ W	0·32	119–0	—	—	×	×	—	—	—	—	—
				260–?100	—	—	×	×	—	—	×	—	—

Station	Date	Position	Surface temperature, ° C.	Depth of net, m.	*E. lucens*	*E. vallentini*	*E. frigida*	*E. superba*	*E. spinifera*	*E. longirostris*	*E. triacantha*	*E. similis*	*E. similis* var. *armata*
760	1931 6. xii	60° 22′ S, 48° 40′ W	−1·00	178–0	—	—	×	×	—	—	—	—	—
				260–140	—	—	—	×	—	—	—	—	—
761	7. xii	59° 46′ S, 45° 30′ W	−0·87	151–0	—	—	×	×	—	—	—	—	—
				290–140	—	—	×	×	—	—	—	—	—
763	8. xii	59° 35′ S, 42° 40′ W	−1·02	124–0	—	—	×	×	—	—	—	—	—
				280–130	—	—	×	×	—	—	—	—	—
765	9. xii	58° 11′ S, 41° 16′ W	0·40	104–0	—	—	×	—	—	—	—	—	—
				206–114	—	—	×	—	—	—	—	—	—
766	10. xii	58° 51′ S, 36° 54′ W	−1·31	102–0	—	—	×	×	—	—	—	—	—
				230–110	—	—	×	×	—	—	—	—	—
767	11. xii	57° 03′ S, 36° 47′ W	0·00	270–118	—	—	×	×	—	—	×	—	—
768	11. xii	56° 21′ S, 36° 35′ W	0·60	119–0	—	—	×	—	—	—	—	—	—
				248–120	—	—	×	—	—	—	×	—	—
769	12. xii	55° 15′ S, 36° 16′ W	0·85	144–0	—	—	×	×	—	—	—	—	—
				342–150	—	—	×	—	—	—	—	—	—
795	1932 6. i	53° 45′ S, 31° 02′ W	0·55	124–0		—	×	×	—	—	—	—	—
				310–124	—	—	×	×	—	—	—	—	—
797	7. i	54° 48′ S, 27° 21′ W	0·76	153–0	—	—	×	×	—	—	—	—	—
				250–122	—	—	×	×	—	—	×	—	—
799	8. i	54° 44′ S, 24° 30′ W	1·30	131–0	—	—	×	×	—	—	×	—	—
				334–130	—	—	×	—	—	—	×	—	—
801	9. i	54° 26′ S, 21° 11′ W	1·71	104–0	—	—	—	—	—	—	—	—	—
				210–128	—	—	×	—	—	—	—	—	—
803	10. i	53° 25′ S, 22° 19′ W	2·70	120–0	—	—	×	—	—	—	×	—	—
				308–130	—	—	×	—	—	—	×	—	—
804	11. i	55° 30′ S, 21° 03′ W	0·53	130–0	—	—	×	×	—	—	—	—	—
				290–104	—	—	×	×	—	—	×	—	—
806	12. i	57° 27′ S, 21° 29′ W	0·51	116–0	—	—	×	—	—	—	—	—	—
				216–144	—	—	×	—	—	—	×	—	—
808	13. i	59° 56′ S, 22° 21′ W	0·12	120–0	—	—	×	×	—	—	—	—	—
				250–100	—	—	×	×	—	—	×	—	—
810	14. i	61° 31′ S, 23° 12′ W	−0·76	166–0	—	—	—	—	—	—	—	—	—
				304–130	—	—	—	—	—	—	—	—	—
811	15. i	62° 44′ S, 23° 18′ W	−1·55	112–0	—	—	—	—	—	—	—	—	—
813	16. i	64° 56′ S, 23° 13′ W	−1·48	135–0	—	—	—	×	—	—	—	—	—
				340–?100	—	—	—	×	—	—	—	—	—
815	17. i	66° 57′ S, 22° 38′ W	−1·20	140–0	—	—	—	×	—	—	—	—	—
				314–188	—	—	—	×	—	—	—	—	—
816	18. i	68° 10′ S, 22° 02′ W	−1·09	133–0	—	—	—	×	—	—	—	—	—
				256–80	—	—	—	×	—	—	—	—	—

Station	Date	Position	Surface temperature, ° C.	Depth of net, m.	*E. lucens*	*E. vallentini*	*E. frigida*	*E. superba*	*E. spinifera*	*E. longirostris*	*E. triacantha*	*E. similis*	*E. similis* var. *armata*
	1932												
817	19. i	69° 59′ S, 23° 53′ W	−1·24	132–0	—	—	—	×	—	—	—	—	—
				260–126	—	—	—	—	—	—	—	—	—
818	20. i	68° 11′ S, 24° 53′ W	−1·45	77–0	—	—	—	×	—	—	—	—	—
819	20. i	67° 24′ S, 25° 41′ W	−1·68	105–0	—	—	—	×	—	—	—	—	—
820	20. i	65° 45′ S, 28° 30′ W	−1·40	110–0	—	—	—	×	—	—	—	—	—
822	23. i	63° 54′ S, 33° 28′ W	−1·40	146–0	—	—	—	—	—	—	—	—	—
				244–130	—	—	—	—	—	—	—	—	—
824	27. i	59° 57′ S, 36° 07′ W	−0·18	157–0	—	—	—	×	—	—	—	—	—
				300–104	—	—	—	—	—	—	—	—	—
825	28. i	56° 31′ S, 36° 00′ W	2·13	117–0	—	—	×	×	—	—	—	—	—
				310–100	—	—	×	×	—	—	×	—	—
828	17. ii	51° 44′ S, 55° 57′ W	7·81	141–0	—	×	—	—	—	—	×	—	—
				?250–100	—	×	—	—	—	—	×	—	—
829	18. ii	51° 43′ S, 50° 32′ W	6·29	140–0	—	×	×	×	—	×	×	×	—
				270–84	—	×	—	—	—	×	×	—	—
830	19. ii	52° 31′ S, 44° 51′ W	5·13	117–0	—	—	×	×	—	—	×	—	—
				356–140	—	—	×	—	—	—	×	—	—
831	20. ii	53° 19′ S, 39° 32′ W	3·32	130–0	—	—	×	—	—	—	×	—	—
				?250–100	—	—	×	×	—	—	×	—	—
833	22. ii	53° 58′ S, 35° 50′ W	2·40	173–0	—	—	×	×	—	—	—	—	—
834	23. ii	52° 17′ S, 31° 01′ W	2·00	146–0	—	—	×	×	—	—	×	—	—
				?250–100	—	—	×	—	—	—	×	—	—
835	25. ii	49° 13′ S, 22° 29′ W	4·54	115–0	—	—	—	—	—	—	—	—	—
836	27. ii	45° 28′ S, 11° 40′ W	7·08	102–0	—	—	—	—	—	—	—	—	—
				?250–100	—	×	—	—	—	—	×	—	—
837	27. ii	44° 44′ S, 9° 38′ W	9·05	125–0	—	×	—	—	—	×	—	×	—
				?250–100	—	×	—	—	—	—	×	×	—
838	28. ii	42° 56′ S, 4° 52′ W	10·10	137–0	×	×	—	—	—	×	—	×	×
				?250–100	×	×	—	—	—	—	—	×	—
839	29. ii	41° 04′ S, 00° 14′ W	12·78	132–0	×	—	—	—	—	×	—	×	×
				?250–100	×	×	—	—	—	×	—	×	×
840	1. iii	39° 21′ S, 4° 20′ E	14·20	101–0	×	×	—	—	×	×	—	×	×
				?250–100	×	×	—	—	×	—	—	×	—
841	2. iii	37° 46′ S, 8° 39′ E	16·82	130–0	—	—	—	—	×	—	—	×	×
				320–140	—	—	—	—	—	—	—	×	×
842	3. iii	36° 05′ S, 13° 34′ E	19·20	155–0	—	—	—	—	—	—	—	×	—
				280–140	—	—	—	—	×	—	—	—	—
844	8. iv	35° 10′ S, 19° 06′ E	20·10	155–0	×	—	—	—	—	—	—	—	—
845	9. iv	38° 08′ S, 20° 56′ E	18·64	148–0	—	—	—	—	×	—	—	×	×
				242–180	×	—	—	—	×	—	—	×	—

Station	Date	Position	Surface tem-perature, ° C.	Depth of net, m.	*E. lucens*	*E. vallen-tini*	*E. frigida*	*E. superba*	*E. spinifera*	*E. longi-rostris*	*E. tri-acantha*	*E. similis*	*E. similis* var. *armata*
846	1932 10. iv	40° 41′ S, 23° 02′ E	17·07	128–0	×	—	—	—	×	×	—	×	×
				370–170	—	—	—	—	—	—	—	×	—
847	11. iv	43° 07′ S, 25° 05′ E	15·13	119–0	—	—	—	—	×	×	—	×	×
				270–196	—	—	—	—	—	—	—	×	—
848	12. iv	45° 48′ S, 27° 14′ E	6·97	117–0	—	×	—	—	—	×	×	×	×
				270–166	—	×	—	—	—	—	—	×	—
849	14. iv	48° 15′ S, 29° 24′ E	7·72	71–0	—	×	—	—	—	×	—	—	×
				210–125	—	×	—	—	—	×	×	×	×
850	15. iv	50° 44′ S, 31° 44′ E	1·90	100–0	—	—	×	—	—	—	×	—	—
				254–140	—	—	×	—	—	—	×	—	—
851	17. iv	56° 22′ S, 37° 22′ E	1·10	125–0	—	—	×	×	—	—	×	—	—
				320–190	—	—	×	—	—	—	×	—	—
852	18. iv	58° 39′ S, 40° 04′ E	0·41	119–0	—	—	×	×	—	—	×	—	—
				370–155	—	—	×	—	—	—	—	—	—
853	19. iv	61° 00′ S, 43° 11′ E	0·01	119–0	—	—	×	×	—	—	×	—	—
				190–108	—	—	×	—	—	—	×	—	—
854	20. iv	63° 30′ S, 46° 25′ E	−0·80	119–0	—	—	—	×	—	—	—	—	—
				248–98	—	—	—	—	—	—	—	—	—
855	20. iv	65° 10′ S, 48° 44′ E	−1·65	125–0	—	—	—	×	—	—	—	—	—
				280–154	—	—	—	×	—	—	—	—	—
856	22. iv	61° 07′ S, 53° 40′ E	0·22	89 0	—	—	×	—	—	—	—	—	—
				224–120	—	—	×	—	—	—	×	—	—
857	24. iv	60° 40′ S, 59° 24′ E	0·00	130–0	—	—	×	—	—	—	—	—	—
				262–140	—	—	×	—	—	—	—	—	—
858	24. iv	60° 10′ S, 63° 55′ E	0·52	88–0	—	—	×	—	—	—	—	—	—
				264–130	—	—	—	—	—	—	×	—	—
859	25. iv	59° 19′ S, 68° 52′ E	0·71	100–0	—	—	×	—	—	—	×	—	—
				210–?140	—	—	×	—	—	—	×	—	—
860	26. iv	57° 56′ S, 73° 59′ E	0·61	119–0	—	—	×	—	—	—	×	—	—
				300–100	—	—	×	—	—	—	—	—	—
861	27. iv	56° 29′ S, 79° 18′ E	0·72	109–0	—	—	×	×	—	—	×	—	—
				270–138	—	—	×	×	—	—	×	—	—
862	28. iv	55° 34′ S, 83° 00′ E	1·80	102–0	—	×	×	×	—	—	×	—	—
				220–98	—	—	×	×	—	—	×	—	—
863	30. iv	54° 15′ S, 88° 22′ E	1·97	90–0	—	×	×	—	—	—	×	—	—
				200–82	—	×	×	—	—	—	×	—	—
865	1. v	52° 48′ S, 94° 56′ E	5·6	116–0	—	—	×	—	—	—	—	—	—
				290–150	—	—	×	—	—	—	×	—	—
866	2. v	51° 23′ S, 96° 26′ E	3·6	98–0	—	×	×	—	—	—	×	—	—
				284–110	—	×	—	—	—	—	×	—	—

Station	Date	Position	Surface temperature, ° C.	Depth of net, m.	*E. lucens*	*E. vallentini*	*E. frigida*	*E. superba*	*E. spinifera*	*E. longirostris*	*E. triacantha*	*E. similis*	*E. similis* var. *armata*
867	1932 2. v	49° 25′ S, 98° 22′ E	5·36	139–0	—	×	—	—	—	×	×	—	—
				330–150	—	×	—	—	—	×	×	—	—
868	3. v	46° 55′ S, 100° 46′ E	6·61	98–0	—	×	—	—	—	×	—	—	—
				240–100	—	×	—	—	—	×	×	—	—
869	5. v	43° 56′ S, 103° 24′ E	10·64	68–0	×	—	—	—	—	×	—	×	×
				240–120	×	—	—	—	—	×	—	×	×
870	6. v	41° 42′ S, 105° 16′ E	10·64	95–0	×	×	—	—	—	×	—	×	×
				250–90	—	—	—	—	—	×	—	×	—
871	7. v	39° 32′ S, 107° 06′ E	12·55	91–0	×	—	—	—	—	×	—	×	×
				240–100	×	—	—	—	×	×	—	×	×
872	7. v	37° 09′ S, 108° 47′ E	16·12	128–0	×	—	—	—	×	—	—	×	×
				300–146	—	—	—	—	—	—	—	×	×
873	8. v	34° 19′ S, 110° 22′ E	20·52	86–0	—	—	—	—	×	—	—	×	×
				220–100	—	—	—	—	×	—	—	×	×
877	18. v	35° 12′ S, 114° 42′ E	21·05	102–0	—	—	—	—	×	—	—	—	×
				250–100	—	—	—	—	×	—	—	×	×
878	19. v	38° 01′ S, 115° 39′ E	18·73	125–0	—	—	—	—	—	—	—	×	×
				294–80	—	—	—	—	×	—	—	×	×
879	19–20. v	40° 57′ S, 116° 46′ E	12·06	86–0	×	—	—	—	×	×	—	×	×
				200–94	×	—	—	—	—	×	—	×	×
880	20–21. v	43° 53′ S, 117° 50′ E	9·75	110–0	×	—	—	—	—	×	—	—	—
				265–90	×	—	—	—	—	—	—	×	—
881	21. v	47° 00′ S, 119° 00′ E	8·30	119–0	×	×	—	—	—	×	—	×	—
				260–100	×	—	—	—	—	×	—	×	—
882	22. v	49° 53′ S, 120° 29′ E	5·05	102–0	—	×	—	—	—	×	×	—	—
				210–80	—	×	—	—	—	×	×	—	—
883	23. v	52° 54′ S, 122° 04′ E	3·72	89–0	—	×	×	—	—	—	×	—	—
				210–90	—	×	×	—	—	—	×	—	—
884	24. v	56° 08′ S, 124° 04′ E	1·92	122–0	—	—	×	—	—	—	×	—	—
				270–90	—	—	×	—	—	—	×	—	—
885	25. v	58° 51′ S, 125° 55′ E	1·01	116–0	—	—	×	—	—	—	×	—	—
				280–120	—	—	×	—	—	—	×	—	—
886	26. v	61° 12′ S, 127° 53′ E	−0·42	132–0	—	—	×	×	—	—	×	—	—
				302–100	—	—	×	×	—	—	×	—	—
887	27. v	63° 41′ S, 130° 07′ E	−1·65	86–0	—	—	×	×	—	—	—	—	—
				235–115	—	—	—	×	—	—	—	—	—
888	28. v	63° 23′ S, 130° 30′ E	−0·14	120–0†				×					
				0–5†				×					
				98–0†				×					
				240–90†				×					

Station	Date	Position	Surface temperature, ° C.	Depth of net, m.	*E. lucens*	*E. vallentini*	*E. frigida*	*E. superba*	*E. spinifera*	*E. longirostris*	*E. tri-acantha*	*E. similis*	*E. similis* var. *armata*
889	1932 29. v	61° 45′ S, 131° 38′ E	0·20	106–0	—	—	×	—	—	—	×	—	—
				290–90	—	—	×	—	—	—	×	—	—
890	29. v	59° 04′ S, 133° 18′ E	0·70	98–0	—	—	×	—	—	—	×	—	—
				240–110	—	—	×	—	—	—	×	—	—
891	30. v	56° 03′ S, 135° 10′ E	3·09	121–0	—	×	×	—	—	—	×	—	—
				260–90	—	×	×	—	—	—	×	—	—
892	31. v	52° 48′ S, 137° 00′ E	5·00	93–0	—	×	—	—	—	×	×	—	—
				220–100	—	×	—	—	—	×	×	—	—
893	1. vi	49° 37′ S, 138° 35′ E	7·91	100–0	—	×	—	—	—	×	—	×	—
				260–100	—	×	—	—	—	×	—	×	—
894	2. vi	46° 31′ S, 139° 50′ E	9·70	91–0	×	—	—	—	—	×	—	×	×
				235–105	×	—	—	—	—	×	—	×	×
895	3. vi	43° 15′ S, 143° 38′ E	11·08	80–0	×	—	—	—	—	×	—	—	×
				250–110	×	—	—	—	×	×	—	×	×
897	15. vi	41° 06′ S, 148° 56′ E	13·53	117–0	×	—	—	—	×	—	—	×	×
				315–120	×	—	—	—	×	—	—	×	×
898	15. vi	43° 55′ S, 149° 32′ E	13·28	128–0	×	—	—	—	×	—	—	—	×
				310–120	×	—	—	—	—	—	—	—	×
899	16. vi	47° 18′ S, 150° 21′ E	10·52	117–0	×	—	—	—	—	×	—	×	×
				330–0	—	—	—	—	—	—	—	×	×
900	17. vi	49° 27′ S, 150° 58′ E	6·92	135–0	—	×	—	—	—	×	—	×	×
				340–140	—	×	—	—	—	×	—	×	—
902	19. vi	52° 24′ S, 151° 11′ E	6·41	120–0	—	—	—	—	—	—	—	—	—
				330–150	—	—	—	—	—	—	—	—	—
903	19. vi	53° 32′ S, 151° 33′ E	4·92	131–0	—	×	—	—	—	×	—	—	—
				370–140	—	×	—	—	—	—	×	—	—
904	20. vi	56° 13′ S, 152° 16′ E	1·98	104–0	—	×	×	—	—	—	×	—	—
				330–120	—	×	×	—	—	—	×	—	—
905	21. vi	59° 12′ S, 153° 11′ E	−0·81	114–0	—	—	×	—	—	—	×	—	—
				320–138	—	—	×	—	—	—	×	—	—
906	22. vi	61° 25′ S, 154° 26′ E	−1·80	140–0	—	—	×	—	—	—	—	—	—
				386–142	—	—	—	—	—	—	—	—	—
911	23. vi	61° 18′ S, 155° 37′ E	−0·78	106–0	—	—	×	—	—	—	×	—	—
				300–110	—	—	×	—	—	—	×	—	—
912	24. vi	61° 02′ S, 158° 26′ E	−1·78	2	—	—	—	×	—	—	—	—	—
919	25. vi	57° 50′ S, 160° 23′ E	1·78	128–0	—	×	×	—	—	—	×	—	—
				306–130	—	×	×	—	—	—	×	—	—
920	26. vi	54° 41′ S, 162° 23′ E	2·91	123–0	—	×	×	—	—	—	×	—	—
				320–100	—	×	×	—	—	—	×	—	—
921	27. vi	51° 39′ S, 163° 52′ E	7·74	114–0	—	×	—	—	—	×	—	×	—
				?250–?100	×	×	—	—	—	×	—	×	×

Station	Date	Position	Surface temperature, ° C.	Depth of net, m.	*E. lucens*	*E. vallentini*	*E. frigida*	*E. superba*	*E. spinifera*	*E. longirostris*	*E. triacantha*	*E. similis*	*E. similis* var. *armata*
922	1932 28. vi	50° 20′ S, 163° 49′ E	8·24	121–0	×	—	—	—	—	—	—	—	—
				338–192	×	×	—	—	—	—	—	×	×
923	29. vi	47° 12′ S, 163° 41′ E	8·88	100–0	×	×	—	—	—	×	—	×	—
				240–138	×	—	—	—	—	×	—	×	×
924	30. vi	44° 17′ S, 165° 46′ E	11·38	95–0	×	—	—	—	×	—	—	—	×
				220–95	×	—	—	—	×	—	—	×	×
925	1. vii	41° 20′ S, 167° 55′ E	12·07	110–0	—	—	—	—	—	—	—	—	—
				282–126	×	—	—	—	×	—	—	—	×
926	2. vii	38° 02′ S, 170° 13′ E	14·18	81–0	—	—	—	—	—	—	—	—	—
				198–100	—	—	—	—	—	—	—	—	—
942	31. viii	42° 46′ S, 176° 15′ E	9·12	132–0	×	—	—	—	—	—	—	—	—
				350–110	×	—	—	—	—	—	—	—	—
943	1. ix	45° 28′ S, 179° 06′ E	7·37	128–0	×	×	—	—	—	×	—	×	—
				356–130	×	×	—	—	—	×	—	×	—
945	3. ix	48° 26′ S, 177° 24′ W	—	102–0	—	—	—	—	—	—	—	—	—
				255–80	—	—	—	—	—	—	—	—	—
946	3. ix	49° 25′ S, 176° 21′ W	6·90	100–0	×	×	—	—	—	×	—	×	×
				270–120	×	×	—	—	—	—	×	×	—
947	4–5. ix	51° 59′ S, 173° 27′ W	6·93	117–0	×	×	—	—	—	×	—	×	—
				310–130	—	×	—	—	—	—	—	×	—
948	6. ix	54° 25′ S, 170° 13′ W	4·74	115–0	—	×	—	—	—	—	×	—	—
				310–132	—	×	—	—	—	—	×	—	—
949	6. ix	56° 50′ S, 166° 56′ W	3·41	117–0	—	×	—	—	—	—	×	—	—
				320–120	—	×	×	—	—	—	×	—	—
950	7. ix	59° 05′ S, 163° 46′ W	0·74	102–0	—	×	×	—	—	—	×	—	—
				300–130	—	—	×	—	—	—	×	—	—
951	8. ix	61° 26′ S, 160° 03′ W	−1·64	117–0	—	—	×	—	—	—	×	—	—
				340–130	—	—	×	—	—	—	×	—	—
954	9. ix	62° 18′ S, 158° 16′ W	−1·60	0–5	—	—	—	×	—	—	—	—	—
955	9. ix	62° 17′ S, 158° 13′ W	−1·50	0–5	—	—	—	×	—	—	—	—	—
956	9. ix	62° 13′ S, 158° 11′ W	−1·76	97–0	—	—	—	×	—	—	—	—	—
				280–100	—	—	—	—	—	—	—	—	—
957	10. ix	61° 56′ S, 155° 50′ W	−1·60	0–2	—	—	—	×	—	—	—	—	—
958	10. ix	61° 54′ S, 155° 42′ W	−1·64	100–0	—	—	—	—	—	—	—	—	—
				260–114	—	—	—	—	—	—	—	—	—
959	11. ix	61° 07′ S, 153° 57′ W	−1·76	91–0	—	—	×	×	—	—	×	—	—
				240–110	—	—	—	×	—	—	×	—	—
960	11–12. ix	58° 31′ S, 150° 03′ W	−1·44	137–0	—	—	×	—	—	—	—	—	—
				290–134	—	—	—	—	—	—	×	—	—
961	12. ix	56° 16′ S, 146° 22′ W	0·42	109–0	—	—	×	—	—	—	×	—	—
				325–144	—	—	×	—	—	—	×	—	—
				290–0	—	—	×	—	—	—	×	—	—

Station	Date	Position	Surface temperature, ° C.	Depth of net, m.	*E. lucens*	*E. vallentini*	*E. frigida*	*E. superba*	*E. spinifera*	*E. longirostris*	*E. triacantha*	*E. similis*	*E. similis* var. *armata*
962	1932 14. ix	54° 03′ S, 142° 25′ W	5·03	124–0	—	×	×	—	—	×	—	—	—
				320–100	—	×	—	—	—	×	×	×	—
963	14. ix	52° 01′ S, 139° 13′ W	6·48	117–0	—	×	—	—	—	×	—	×	—
				320–128	×	×	—	—	—	×	—	×	—
964	15. ix	49° 42′ S, 135° 33′ W	6·86	110–0	×	×	—	—	—	×	—	×	—
				?250–100	×	×	—	—	—	×	—	×	—
965	16. ix	47° 17′ S, 132° 25′ W	7·10	121–0	×	×	—	—	—	×	—	×	—
				310–132	—	×	—	—	—	—	—	—	—
966	17. ix	44° 40′ S, 129° 28′ W	8·50	102–0	×	—	—	—	×	—	—	×	×
				250–100	×	—	—	—	×	—	—	×	—
967	19. ix	41° 03′ S, 126° 04′ W	9·70	110–0	—	—	—	—	×	—	—	×	—
				306–145	—	—	—	—	×	—	—	—	—
968	19. ix	42° 30′ S, 124° 52′ W	9·30	86–0	×	—	—	—	×	—	—	×	×
				250–106	×	—	—	—	×	—	—	×	—
969	20. ix	45° 36′ S, 122° 09′ W	7·81	89–0	×	—	—	—	×	—	—	×	—
				250–100	—	—	—	—	—	—	—	×	×
970	25. ix	55° 27′ S, 115° 01′ W	3·70	141–0	—	—	—	—	—	—	—	—	—
				380–110	—	—	—	—	—	—	—	—	—
971	25. ix	56° 23′ S, 113° 58′ W	4·61	117–0	—	×	—	—	—	×	—	—	—
				340–120	—	×	—	—	—	×	—	×	—
972	26. ix	59° 22′ S, 109° 59′ W	1·61	128–0	—	×	×	—	—	—	×	—	—
				?300–128	—	—	×	—	—	—	×	—	—
973	27. ix	61° 48′ S, 105° 37′ W	1·59	100–0	—	—	×	—	—	—	×	—	—
				270–120	—	—	×	—	—	—	×	—	—
974	28. ix	63° 57′ S, 101° 16′ W	−0·88	115–0	—	—	—	—	—	—	—	—	—
				314–114	—	—	×	—	—	—	—	—	—
975	29. ix	61° 30′ S, 94° 07′ W	0·43	117–0	—	—	×	—	—	—	×	—	—
				290–104	—	—	×	—	—	—	×	—	—
976	30. ix	59° 22′ S, 89° 04′ W	2·69	73–0	—	×	×	—	—	—	×	—	—
				190–84	—	—	×	—	—	—	×	—	—
977	1. x	57° 18′ S, 84° 29′ W	4·61	119–0	—	×	—	—	—	×	×	×	—
				318–140	—	×	—	—	—	×	×	—	—
978	2. x	55° 18′ S, 80° 08′ W	4·97	117–0	—	×	—	—	—	×	—	—	—
				298–108	—	×	—	—	—	—	×	×	—
979	15. x	51° 00′ S, 62° 36′ W	5·59	117–0	—	—	—	—	—	—	—	—	—
980	15. x	51° 01′ S, 64° 44′ W	5·10	104–0	×	×	—	—	—	—	—	—	—
981	16. x	51° 01′ S, 66° 52′ W	5·80	80–0	—	—	—	—	—	—	—	—	—
983	23. x	55° 10′ S, 76° 05′ W	5·91	121–0	—	×	—	—	—	—	×	—	—
				300–80	—	×	—	—	—	—	—	—	—
985	24. x	55° 22′ S, 79° 24′ W	4·96	113–0	—	×	—	—	—	—	×	—	—
				290–110	—	×	—	—	—	—	×	×	—

Station	Date	Position	Surface temperature, ° C.	Depth of net, m.	*E. lucens*	*E. vallentini*	*E. frigida*	*E. superba*	*E. spinifera*	*E. longirostris*	*E. tri-acantha*	*E. similis*	*E. similis* var. *armata*
986	1932 25. x	56° 29′ S, 79° 28′ W	4·89	102–0	—	—	—	—	—	—	—	—	—
				244–114	—	×	—	—	—	—	—	—	—
988	26. x	59° 19′ S, 79° 40′ W	3·89	88–0	—	×	×	—	—	×	×	—	—
				224–74	—	×	—	—	—	—	×	×	—
990	27. x	61° 56′ S, 79° 57′ W	3·06	96–0	—	—	—	—	—	—	×	—	—
				276–100	—	×	×	—	—	—	×	—	—
992	28. x	64° 19′ S, 80° 06′ W	−1·52	99–0	—	—	—	—	—	—	—	—	—
				270–110	—	—	×	—	—	—	—	—	—
994	29. x	66° 46′ S, 80° 20′ W	−1·69	113–0	—	—	—	—	—	—	—	—	—
				270–90	—	—	×	—	—	—	—	—	—
				0–5	—	—	—	×	—	—	—	—	—
995	30. x	67° 06′ S, 79° 56′ W	−1·80	320–120	—	—	—	—	—	—	—	—	—
				320–120*	—	—	—	×	—	—	—	—	—
996	30. x	66° 54′ S, 78° 52′ W	−1·70	100–0	—	—	—	—	—	—	—	—	—
				350–90	—	—	—	—	—	—	—	—	—
				0–5	—	—	—	×	—	—	—	—	—
997	30. x	66° 37′ S, 78° 24′ W	−1·72	4–5	—	—	—	—	—	—	—	—	—
				10	—	—	—	—	—	—	—	—	—
998	31. x	66° 41′ S, 75° 14′ W	−1·82	3–4	—	—	—	×	—	—	—	—	—
999	31. x	66° 56′ S, 73° 51′ W	−1·73	151–0	—	—	—	—	—	—	—	—	—
				0–5	—	—	—	×	—	—	—	—	—
				151–0*	—	—	—	×	—	—	—	—	—
1000	1. xi	65° 07′ S, 71° 40′ W	−1·72	128–0	—	—	—	×	—	—	—	—	—
				300–110	—	—	—	—	—	—	—	—	—
1001	1. xi	64° 54′ S, 68° 44′ W	−1·70	95–0	—	—	—	×	—	—	—	—	—
				230–?66	—	—	×	×	—	—	—	—	—
				0–5	—	—	—	×	—	—	—	—	—
1002	2. xi	64° 23′ S, 65° 44′ W	−1·68	86–0	—	—	—	×	—	—	—	—	—
				230–94	—	—	—	×	—	—	—	—	—
1003	2. xi	63° 41′ S, 63° 08′ W	−1·40	115–0	—	—	—	×	—	—	—	—	—
1013	6. xi	61° 57′ S, 56° 20′ W	−1·08	93–0	—	—	×	×	—	—	—	—	—
				314–140	—	—	×	×	—	—	—	—	—
1014	7. xi	61° 27′ S, 56° 20′ W	−1·06	144–0	—	—	×	×	—	—	—	—	—
1015	7. xi	58° 53′ S, 56° 19′ W	−0·41	128–0	—	—	×	×	—	—	—	—	—
				350–120	—	—	×	×	—	—	×	—	—
1017	8. xi	56° 00′ S, 56° 08′ W	0·70	110–0	—	—	×	×	—	—	×	—	—
				330–150	—	—	—	—	—	—	×	—	—
1019	9. xi	53° 23′ S, 56° 02′ W	5·11	119–0	—	×	—	—	—	×	×	—	—
				320–110	—	×	—	—	—	—	×	×	—
1021	13. xi	51° 20′ S, 55° 20′ W	5·80	120–0	—	×	—	—	—	—	×	—	—
				315–130	—	×	—	—	—	—	×	×	—

Station	Date	Position	Surface temperature, ° C.	Depth of net, m.	*E. lucens*	*E. vallentini*	*E. frigida*	*E. superba*	*E. spinifera*	*E. longirostris*	*E. triacantha*	*E. similis*	*E. similis* var. *armata*
1023	1932 16. xi	50° 49′ S, 51° 33′ W	5·31	112–0	—	×	—	—	—	×	×	×	—
				318–130	—	—	×	—	—	—	×	—	—
1025	17. xi	50° 18′ S, 47° 12′ W	5·02	140–0	×	×	—	—	—	—	×	×	—
				400–160	—	—	×	—	—	—	×	—	—
1027	18. xi	51° 20′ S, 44° 41′ W	3·63	100–0	—	—	×	×	—	—	×	—	—
				300–125	—	—	×	×	—	—	×	—	—
1029	19. xi	54° 21′ S, 44° 36′ W	1·44	100–0	—	—	×	×	—	—	×	—	—
				300–130	—	—	×	—	—	—	—	—	—
1031	20. xi	56° 56′ S, 44° 32′ W	0·22	149–0	—	—	×	×	—	—	×	—	—
				?370–104	—	—	×	—	—	—	—	—	—
1033	21. xi	59° 38′ S, 44° 31′ W	0·19	113–0	—	—	×	×	—	—	—	—	—
				?270–100	—	—	×	—	—	—	×	—	—
1034	24. xi	60° 58′ S, 44° 40′ W	−1·19	165–0	—	—	—	×	—	—	—	—	—
1035	24. xi	61° 56′ S, 44° 44′ W	−1·21	100–0	—	—	×	×	—	—	—	—	—
				274–116	—	—	—	—	—	—	—	—	—
1038	25. xi	61° 39′ S, 40° 00′ W	−1·31	151–0	—	—	—	×	—	—	—	—	—
				375–110	—	—	—	—	—	—	—	—	—
1039	26. xi	61° 30′ S, 37° 14′ W	−0·99	128–0†				×					
1041	26. xi	60° 31′ S, 36° 19′ W	−1·05	84–0	—	—	×	×	—	—	—	—	—
				250–100	—	—	—	—	—	—	—	—	—
1044	27. xi	60° 01′ S, 32° 22′ W	−1·21	0–5	—	—	—	×	—	—	—	—	—
				117–0	—	—	×	×	—	—	—	—	—
				296–100	—	—	—	×	—	—	—	—	—
1045	29. xi	58° 33′ S, 27° 05′ W	−1·44	0–5	—	—	×	×	—	—	×	—	—
				100–0	—	—	—	—	—	—	—	—	—
				256–110	—	—	×	—	—	—	—	—	—
1046	29. xi	58° 09′ S, 26° 52′ W	−1·01	330–90*†				×					
1047	30. xi	57° 27′ S, 26° 09′ W	−0·93	84–0	—	—	—	—	—	—	—	—	—
				230–86	—	—	×	×	—	—	—	—	—
1048	30. xi	56° 32′ S, 27° 22′ W	−0·65	119–0	—	—	×	—	—	—	—	—	—
				340–140	—	—	×	—	—	—	—	—	—
1050	1. xii	53° 47′ S, 31° 09′ W	0·01	103–0	—	—	×	×	—	—	—	—	—
				295–104	—	—	×	×	—	—	—	—	—
1052	2. xii	52° 10′ S, 33° 22′ W	1·00	133–0	—	—	×	×	—	—	×	—	—
				340–100	—	—	×	×	—	—	×	—	—
1154	1933 12. iii	69° 15′ S, 9° 37′ W	−1·57	0–5†				×					
				0–5†				×					

APPENDIX II

Table showing the stations at which the larval and post-larval stages of Euphausia frigida, E. vallentini, E. triacantha, E. longirostris *and* E. spinifera *occurred.*

Euphausia frigida

Station	Date	Position	Surface temperature ° C.	Net	Depth of net m.	Calyptopis		Furcilia													Fraction of catch examined
						Second	Third	3 non-setose pleopods	Stage I	5 non-setose pleopods	Stage II	Stage III	Antennal endopod unsegmented, 5 terminal spines on telson	Antennal endopod segmented, 7 terminal spines on telson	Antennal endopod segmented, 6 terminal spines on telson	Stage IV	4 terminal spines on telson	Stage V	2 terminal spines on telson	Stage VI	
	1931																				
765	9. xii	58° 11′ S, 41° 16′ W	0·40	1-m.	104–0	—	—	—	3	—	8	5	—	—	—	—	—	—	—	—	1/5
766	10. xii	58° 51′ S, 36° 54′ W	−1·31	,,	102–0	—	—	—	1	—	1	3	—	—	—	—	—	—	—	—	1
767	11. xii	57° 03′ S, 36° 47′ W	0·00	,,	270–118	—	—	—	1	—	2	—	—	—	—	—	—	—	—	—	1
768	11. xii	56° 21′ S, 36° 35′ W	0·60	,,	119–0	—	—	—	—	—	12	15	—	—	2	8	—	1	2	—	1
769	12. xii	55° 15′ S, 36° 16′ W	0·85	,,	144–0	—	—	—	7	—	1	—	—	—	—	—	—	—	—	—	1/5
	1932																				
799	8. i	54° 44′ S, 24° 30′ W	1·30	,,	164–0	—	—	—	—	—	—	—	—	—	—	—	—	—	1	16	1
801	9. i	54° 26′ S, 21° 11′ W	1·71	,,	210–128	—	—	—	—	—	—	—	—	—	—	—	—	1	—	12	1/2
831	20. ii	53° 19′ S, 39° 32′ W	3·32	,,	130–0	—	—	—	—	—	—	—	—	—	—	1	—	—	—	3	1/10
851	17. iv	56° 22′ S, 37° 22′ E	1·10	,,	125–0	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	1
865	1. v	52° 48′ S, 94° 56′ E	5·60	,,	290–?150	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	1
1016	8. xi	57° 19′ S, 56° 20′ W	−0·20	,,	113–0	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	1
1025	17. xi	50° 18′ S, 47° 12′ W	5·02	,,	140–0	—	—	—	—	—	1	3	—	—	—	—	—	1	—	2	1/10
1026	18. xi	50° 00′ S, 44° 41′ W	4·60	,,	285–130	—	—	—	1	—	1	—	—	—	—	—	—	—	—	—	1
1028	19. xi	52° 55′ S, 44° 38′ W	2·40	,,	330–135	—	1	—	—	—	—	3	—	—	—	—	—	—	—	—	1
				70-cm.	50–0	—	—	—	6	—	2	2	—	—	—	—	—	—	—	—	1
				,,	100–50	—	2	—	22	—	—	1	—	—	—	—	—	—	—	—	1
				,,	250–100	1	2	—	—	—	—	—	—	—	—	—	—	—	—	—	1
1029	19. xi	54° 21′ S, 44° 36′ W	1·44	1-m.	100–0	—	11	—	40	—	130	60	—	—	—	3	1	1	—	—	1
1030	20. xi	55 43′ S, 44° 31′ W	1·74	70-cm.	50–0	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	1
				,,	100–50	12	8	—	9	—	—	—	—	—	—	—	—	—	—	—	1
1031	20. xi	56° 56′ S, 44° 32′ W	0·22	1-m.	149–0	—	—	—	2	1	1	—	—	—	—	—	—	—	—	—	1
1032	21. xi	58° 29′ S, 44° 34′ W	0·20	,,	107–0	—	2	—	1	—	1	—	—	—	—	—	—	—	—	—	1
1052	2. xii	52° 10′ S, 33° 22′ W	1·00	,,	133–0	—	—	—	—	—	2	42	—	—	—	32	1	11	1	4	1/5
				,,	340–100	—	—	—	2	—	5	20	1	2	—	19	—	5	1	5	1
1053	3. xii	51° 09′ S, 34° 35′ W	2·15	,,	360–90	—	3	1	6	—	6	30	—	2	—	29	—	15	4	21	1
				70-cm.	100–50	—	1	—	4	—	6	19	—	—	—	11	—	1	—	2	1
				,,	250–100	4	10	—	7	—	2	—	—	—	—	—	—	—	—	—	1
1056	4. xii	50° 18′ S, 37° 04′ W	4·31	1-m.	100–0	—	—	—	—	—	2	5	—	—	—	4	—	5	—	14	1/5
				,,	340–100	—	—	—	—	—	1	5	—	—	—	9	2	3	1	19	1
1057	5. xii	51° 55′ S, 36° 52′ W	1·08	70-cm.	100–50	—	—	—	3	—	6	3	—	—	—	1	—	—	—	—	1
				,,	250–100	6	9	—	6	—	4	1	—	—	—	—	—	—	—	—	1

Euphausia vallentini

Station	Date	Position	Surface temperature ° C.	Net	Depth of net m.	Calyptopis		Furcilia									Post-larval stages	Fraction of catch examined
						Second	Third	Stage I	3 setose, 2 non-setose pleopods	Stage II	Stage III	Stage IV	With 4 terminal spines on telson	Stage V	With 2 terminal spines on telson	Stage VI		
828	1932 17. ii	51° 44′ S, 55° 57′ W	7·81	1-m.	141–0	—	—	—	—	—	—	—	—	—	—	7	—	1/5
837	27. ii	44° 44′ S, 9° 38′ W	9·05	,,	125–0	—	—	—	—	—	—	—	—	—	—	—	67	1
986	25. x	56° 29′ S, 79° 28′ W	4·89	,,	244–144	—	—	—	—	—	—	—	—	—	—	1	—	1
1018	9. xi	54° 44′ S, 55° 56′ W	4·97	,,	119–0	—	1	5	1	2	1	—	—	2	—	—	—	1
				70-cm.	50–0	13	15	2	—	—	—	—	—	—	—	—	—	1
				,,	100–50	12	32	17	—	2	—	—	—	—	—	—	—	1
				,,	250–100	—	2	30	2	22	30	4	1	26	2	16	—	1
1019	9. xi	53° 23′ S, 56° 02′ W	5·11	1-m.	119–0	—	—	3	—	16	27	3	—	20	4	13	—	1/5
1021	13. xi	51° 20′ S, 55° 20′ W	5·80	,,	120–0	—	—	1	—	1	60	10	10	35	7	64	—	1/5
				,,	315–150	—	—	4	—	1	—	1	1	4	—	1	—	1
1023	16. xi	50° 49′ S, 51° 33′ W	5·31	,,	112–0	—	—	—	—	—	9	2	—	4	1	3	—	1/4
1025	17. xi	50° 18′ S, 47° 12′ W	5·02	,,	140–0	—	—	—	—	2	5	—	—	2	—	—	—	1/10
1026	18. xi	50° 00′ S, 44° 41′ W	4·60	,,	285–130	—	—	—	—	—	1	—	—	—	1	—	—	1
1030	20. xi	55° 43′ S, 44° 31′ W	1·74	,,	340–135	—	—	—	—	1	—	—	—	—	—	—	—	1
1056	4. xii	50° 18′ S, 37° 04′ W	4·31	,,	100–0	—	—	—	—	—	2	—	—	—	—	6	—	1/5

Euphausia triacantha

Station	Date	Position	Surface temperature ° C.	Net	Depth of net m.	Calyptopis		Furcilia													Fraction of catch examined
						Second	Third	Stage I	5 non-setose pleopods	3 setose, 2 non-setose pleopods	Stage II	Stage III	Antennal endopod segmented, 8 terminal spines on telson	Stage IV	6 terminal spines on telson	Stage V	4 terminal spines on telson	Stage VI	2 terminal spines on telson	Stage VII	
731	1931 20. xi	60° 36′ S, 75° 04′ W	1·81	1-m.	62–0	—	4	—	—	—	—	—	—	—	—	—	—	—	—	—	1/10
753	2. xii	52° 02′ S, 49° 12′ W	2·59	,,	280–110	—	—	—	—	—	—	3	—	—	—	—	—	—	—	—	1
769	12. xii	55° 15′ S, 36° 16′ W	0·85	,,	144–0	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	1
775	16. xii	50° 48′ S, 37° 22′ W	3·73	,,	106–0	—	—	—	—	—	—	13	—	23	—	17	—	2	—	2	1
803	1932 10. i	53° 25′ S, 22° 19′ W	2·70	,,	120–0	—	—	—	—	—	4	17	1	39	9	45	—	4	3	8	1
828	17. ii	51° 44′ S, 55° 57′ W	7·81	,,	141–0	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	1
				,,	250–100	—	—	—	—	—	1	3	—	—	—	—	—	—	—	—	1
829	18. ii	51° 43′ S, 50° 32′ W	6·29	,,	270–84	—	—	—	—	—	1	2	—	—	—	2	—	—	—	—	1
830	19. ii	52° 31′ S, 44° 51′ W	5·13	,,	117–0	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	1
				,,	356–140	—	—	—	—	—	—	—	—	1	—	—	—	1	—	—	1
836	27. ii	45° 28′ S, 11° 40′ W	7·08	,,	?250–100	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1	1
978	2. x	55° 18′ S, 80° 08′ W	4·97	,,	117–0	2	1	—	—	—	—	—	—	—	—	—	—	—	—	—	1
				,,	298–108	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
983	23. x	55° 10′ S, 76° 05′ W	5·91	,,	121–0	—	1	5	—	1	3	1	—	—	—	—	—	—	—	—	1
988	26. x	59° 19′ S, 79° 40′ W	3·89	,,	88–0	1	4	3	—	—	—	—	—	—	—	—	—	—	—	—	1
989	27. x	60° 39′ S, 79° 50′ W	3·43	,,	270–98	7	15	2	—	—	—	—	—	—	—	—	—	—	—	—	1
990	27. x	61° 56′ S, 79° 57′ W	3·06	,,	96–0	—	2	1	—	—	—	—	—	—	—	—	—	—	—	—	1
1018	9. xi	54° 44′ S, 55° 56′ W	4·97	,,	119–0	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	1
				,,	322–156	—	—	2	—	—	1	4	—	—	—	—	—	—	—	—	1/5
				70-cm.	250–100	—	4	6	—	—	1	—	—	—	—	—	—	—	—	—	1
1021	13. xi	51° 20′ S, 55° 20′ W	5·80	1-m.	120–0	—	2	6	—	—	4	1	—	—	—	—	—	—	—	—	1/5
1026	18. xi	50° 00′ S, 44° 41′ W	4·60	,,	285–130	—	—	97	1	—	82	32	—	—	—	—	—	—	—	—	1
				70-cm.	100–50	—	—	—	—	—	2	1	—	—	—	—	—	—	—	—	1
				,,	250–100	2	5	12	—	—	6	4	—	—	—	—	—	—	—	—	1
1028	19. xi	52° 55′ S, 44° 38′ W	2·40	1-m.	119–0	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	1
				,,	330–135	—	—	2	—	—	1	—	—	—	—	—	—	—	—	—	1
1030	20. xi	55° 43′ S, 44° 31′ W	1·74	,,	126–0	1	8	23	—	—	9	—	—	—	—	—	—	—	—	—	1
				70-cm.	100–50	3	10	5	—	—	—	—	—	—	—	—	—	—	—	—	1
				,,	250–100	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	1
1031	20. xi	56° 56′ S, 44° 32′ W	0·22	1-m.	149–0	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	1
1053	3. xii	51° 09′ S, 34° 35′ W	2·15	,,	360–90	1	25	91	3	—	170	144	1	45	—	—	—	—	—	—	1
				70-cm.	250–100	5	5	23	1	—	17	2	—	—	—	—	—	—	—	—	1
1055	4. xii	49° 03′ S, 37° 17′ W	4·89	1-m.	121–0	—	—	1	—	—	10	—	—	—	—	—	—	—	—	—	1
				,,	298–134	—	—	—	—	—	16	17	—	19	—	1	—	—	—	—	1
				70-cm.	100–80	2	—	1	—	—	1	—	—	—	—	—	—	—	—	—	1
1061	10. xii	53° 01′ S, 37° 16′ W	1·42	1-m.	103–0	—	1	6	—	—	1	—	—	—	—	—	—	—	—	—	1
				,,	250–100	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	1
1062	11. xii	52° 41′ S, 37° 23′ W	1·21	,,	93–0	—	—	4	—	—	3	—	—	—	—	—	—	—	—	—	1
					240–100	—	3	14	—	—	9	1	—	—	—	—	—	—	—	—	1
1117	1933 7. ii	57° 46′ S, 60° 31′ W	4·37	,,	119–0	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	1
1119	8. ii	55° 08′ S, 59° 18′ W	6·63	,,	100–0	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	1

Station	Date	Position	Surface temperature C.	Net	Depth of net m.	Calyptopis		Furcilia									Post-larval stages
						Second	Third	Stage I	Stage II	Stage III	Stage IV	Antennal endopod segmented, 6 terminal spines on telson	Stage V	4 terminal spines on telson	Stage VI	Stage VII	
	1932																
838	28. ii.	42° 56′ S, 4° 52′ W	10·10	1-m.	137–0	9	19	16	5	—	—	—	—	—	—	—	20
839	29. ii	41° 04′ S, 00° 14′ W	12·78	,,	132–0	—	1	—	1	—	4	1	1	3	2	—	11
				,,	250–100	—	—	—	—	—	1	—	—	—	—	—	5
840	1. iii	39° 21′ S, 4° 20′ E	14·20	,,	250–100	—	—	—	—	—	—	—	1	—	—	—	—
847	11. iv	43° 07′ S, 25° 05′ E	15·13	,,	119–0	—	—	—	—	1	—	—	—	—	1	—	—
849	14. iv	48° 15′ S, 29° 24′ E	7·72	,,	71–0	—	—	—	—	1	—	—	—	—	—	—	—
869	5. v	43° 56′ S, 103° 24′ E	10·64	,,	240–120	—	—	—	—	—	—	—	—	—	1	1	3
870	6. v	41° 42′ S, 105° 16′ E	10·64	,,	95–0	—	—	—	—	—	—	—	—	—	1	—	2
894	2. vi	46° 31′ S, 139° 50′ E	9·70	,,	91–0	—	—	—	—	—	—	—	—	—	—	—	2

Entire catch of each haul examined.

Euphausia spinifera

Station	Date	Position	Surface temperature ° C.	Net	Depth of net m.	Calyptopis			Furcilia										Post-larval stages
						Second	Third		Stage I		1 setose, 2 non-setose pleopods	Stage II	Stage III	Stage IV	Stage V	Stage VI	Stage VII		
							Large	Small	Large	Small									
	1930																		
446	9. x	36° 14′ S, 16° 10′ E	15·35	1-m.	106–0	—	—	—	—	—	—	—	—	4	3	4	9		8
	1931																		
713	29. x	31° 37′ S, 45° 00′ W	18·88	2-m.	200–0	—	—	—	—	—	—	—	—	—	—	—	—		1
	1932																		
841	2. iii	37° 46′ S, 8° 39′ E	16·82	1-m.	130–0	—	1	1	1	1	—	—	1	—	—	1	—		—
845	9. iv	38° 08′ S, 20° 56′ E	18·64	,,	242–180	—	—	—	—	2	—	—	1	—	—	—	—		—
847	11. iv	43° 07′ S, 25° 05′ E	15·13	,,	119–0	—	—	—	—	1	—	1	1	1	—	—	—		—
967	19. ix	41° 03′ S, 126° 04′ W	9·70	,,	306–145	—	—	—	—	—	1	—	—	1	—	—	—		—
968	19. ix	42° 30′ S, 124° 52′ W	9·30	,,	86–0	1	2	—	6	—	—	1	—	—	—	—	—		—
969	20. ix	45° 36′ S, 122° 09′ W	7·81	,,	89–0	—	1	—	—	—	—	—	—	—	—	—	—		—

Entire catch of each haul examined.

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THE REPRODUCTIVE SYSTEM OF *EUPHAUSIA SUPERBA*

By

HELENE E. BARGMANN, PH.D.

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THE REPRODUCTIVE SYSTEM OF *EUPHAUSIA SUPERBA*

By Helene E. Bargmann, Ph.D.

(Plates I–V; Text-figs. 1–26)

INTRODUCTION

This account of the reproductive system of *Euphausia superba* forms the introduction to a further paper on the development and distribution of post-larval and adult krill.

The composition of any specific population is estimated not merely by length measurements, but by the degree of maturity to which the individual members of each sex have attained, and before the life history and distribution of a species can be described, it is essential that these facts should be ascertained.

In *E. superba*, external sexual characters appear first in half-grown specimens, but in a great number of such individuals these characters are not yet developed. In this investigation, therefore, to ensure correct sex determination, all the specimens both large and small were measured and dissected, and the degree of development of the external and internal genitalia was noted. Some new anatomical details resulting from this intensive investigation are set out in this short paper.

MATERIAL AND METHODS

John (1936), in his paper referring to the distribution of the genus *Euphausia*, places *E. superba* in his Southern Group, which is circumpolar in range. This species, which can occur in enormous numbers, is found in the colder water of the Antarctic Zone, and along the edge of and under the pack-ice. No detailed list of stations from which material was obtained is appended here, since it belongs more appropriately to the main paper, where it will be included.

The post-larval and adult specimens in the Discovery Collections were preserved in alcohol, and in consequence the varying degrees of shrinkage due to the use of different preservatives, which Fraser (1936) encountered in his work on the larval forms, did not exist. Some specimens were, of course, more flexed than others, but each was straightened out as completely as possible on an opal glass scale, and its length from the anterior margin of the eyes to the end of the telson determined to the nearest millimetre. The anterior edge of the eyes, rather than the tip of the rostrum, was selected as one limit of measurement, being readily distinguished and less liable to damage.

The carapace and body muscles were then dissected from the left side under a binocular microscope, and the reproductive system was examined. The sex and the approximate age of the specimen having been thus determined, external sexual characters, if developed, were also noted. In all, 5564 specimens ranging from 16 to 64 mm. were dissected, of which 2867 were males and 2697 females.

Two series of sections, one longitudinal and the other transverse, were made of the reproductive region of two adult females, each measuring 50 mm. and having spermatophores attached to the thelycum. The course of the oviducts was traced in these sections, the more important of which were photographed microscopically (cf. Plates II–V).

Adult females were also used for a series of thick transverse hand-sections (about ½ cm. thick) through the fifth, sixth and seventh thoracic segments, from which, after further *dissection*, Fig. 23 was drawn.

Finally, in order to determine the approximate number of eggs laid by one female, the ovaries of two gravid females were removed from the body, and the eggs were dissected out on to a large squared slide, separated from one another and counted.

ACKNOWLEDGEMENTS

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EXTERNAL CHARACTERS

Euphausia superba is shrimp-like in appearance, attaining when fully grown a length of between 50 and 65 mm. The living specimens (Pl. I) are remarkable for their transparency and their bright coral-red pigmentation, which often makes the occurrence of the large surface shoals of this animal very conspicuous. The body is covered with a thin, chitinous exoskeleton, which, although much thickened after the final moult before maturity, is always delicate enough to allow the internal organs and muscles to be seen. The adult is thus not very heavily armoured, spines being present only on the carapace and not on the abdomen, except for a well-marked pre-anal spine in both males and females.

The carapace is not very extensive in either sex, although the whole body of the adult female is thicker, heavier and longer than that of the male. In a mature female 58 mm. in length, the depth of the carapace measured 13·5 mm. and the width 6·5 mm., whereas in a male 56 mm. long, the depth of the carapace was only 9 mm. and the width 4·5 mm. The ventral margin of the carapace does not overhang the bases of the legs, and the gills which project freely into the water are more exposed in the male than in the female.

In the adults of both sexes there is a spine on each anterior, lateral corner of the carapace, this spine being sharp and long in the female, and blunt and short in the male. The rostrum is bluntly pointed in the female and projects forwards to the anterior margin of the eye, whereas in the male it is rounded and extends only over two-thirds of the eye.

The adult female has a pair of well-marked forwardly projecting lateral denticles on the ventral margin of the carapace at the level of the second pair of thoracic legs. There is only the slightest indication of such structures in the adult male, the denticles, which are present in young specimens, diminishing with each successive moult.

The epimera of the abdominal segments are large, flat and blade-like. In the female they are produced posteriorly, in the male both posteriorly and anteriorly, except the first pair which alone project posteriorly. The last pair are triangular in both sexes, and are very large in the male.

The eye-stalks are short and carry large well-developed eyes, which are slightly larger in the male than in the female.

The antennular peduncles are three-jointed and exhibit small sexual differences. These have been described in detail by John (1936) in his paper on the genus *Euphausia*, so that nothing further need be said here.

The basal part of the antenna is divided rather indistinctly into two parts, the first carrying the opening of the green gland and the second the antennal scale and flagellum. In the female, the antennal scale is truncate, extending about one-third along the third antennular joint. It carries a small sturdy denticle on its outer apex. In the male, the scale is more rounded, extending to the end of the second antennular joint, with a thinner, smaller denticle.

The mouth-parts and thoracic legs are similar in both sexes, except the sixth pair of thoracic legs in the female, the coxopodites of which are modified to form the thelycum. This structure will be described in more detail later in the paper. The oviducts open between the thelycum and the ventral surface of the sixth thoracic segment. In the male the external genital pores are on the sternum of the eighth thoracic segment.

The pleopods are all similar in the female, but in the male the first two pairs are much modified to form copulatory organs, an account of the development and structure of which will be given later.

I do not propose to describe the external characters of *E. superba* in any more detail; they have been fully dealt with by Sars (1885) and subsequent workers. My object has been to draw attention to the chief external differences between the adult males and females.

REPRODUCTIVE SYSTEM

PREVIOUS WORK

Until the publication of two important papers, one by Zimmer in 1913 and the other by Raab in 1915, work on the reproductive system of the Euphausiacea was fragmentary.

The first description of the system, though a short one, was given by Claus in 1868 of the genus *Euphausia*, together with a figure showing a spermatophore attached to the ventral surface of the female "unter zwei vorstehenden Platten". The work of Boas

(1883) followed on a genus called by him *Thysanopus*, but which according to the description of the thoracic appendages was evidently the genus *Thysanopoda*.

A general account of the reproductive system of the genus *Euphausia* was given by G. O. Sars (1885) in his report of the Schizopoda of the Challenger Expedition, but no adult male or female specimens were obtained and the account is therefore incomplete.

Chun (1896) reviewed the previous work on the group and described the system in *Stylocheiron*, giving an account of the histology of the ovary and testis.

Zimmer (1913) worked on a considerable quantity of *Euphausia superba* Dana, and although the material was not sufficiently well preserved for histological examination, he was able to describe the general anatomy and to discuss the function of the various structures. His account was supplemented by Raab's work, which appeared in 1915, on *Meganyctiphanes norvegica* M. Sars and *Euphausia krohnii* Brandt. The material available was specially preserved and Raab was able to employ histological methods; consequently his descriptions are the most detailed of any published hitherto.

None of the above workers, however, had access to such a large collection as that made during the course of the Discovery Investigations, and they were therefore unable to record a complete series of growth stages from the earliest appearance of the reproductive system to sexual maturity.

MALE REPRODUCTIVE SYSTEM

The general plan of the male reproductive system can be seen in post-larval specimens of 18–20 mm. in length, in which, however, there is as a rule no sign of modification in the pleopods.

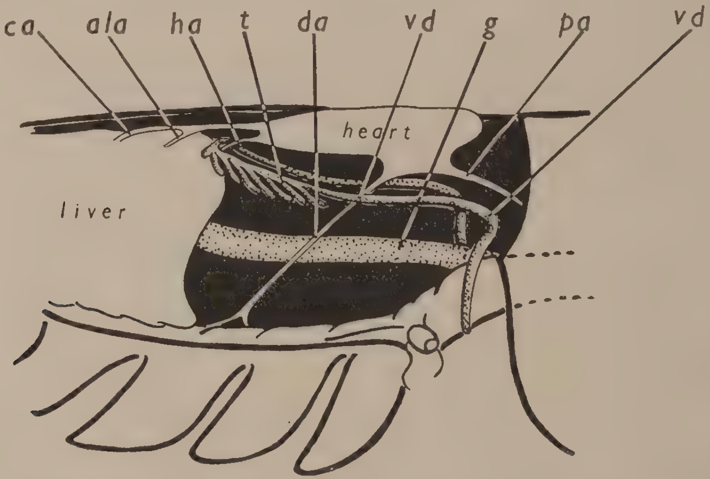

*Fig. 1. Dissection to show the development of the male reproductive system. × 15. *ala*, anterior lateral artery; *ca*, cephalic aorta; *da*, descending aorta; *g*, gut; *ha*, hepatic artery; *pa*, posterior aorta; *t*, testis; *vd*, vas deferens.

The testis *t* (Fig. 1) lies partly below the heart and partly on the dorsal surface of the liver to which it is attached by a fold of mesentery. It consists of fifteen finger-like follicles arranged round the outer side of a horseshoe-shaped band. The anterior follicles are short and broad, but the median and posterior ones become gradually more elongated. The number of follicles appears to be fairly constant, there being generally seven on each side and one occupying a median, anterior position. In the young specimen, each follicle is distinctly separate from its neighbours, but in the adult all the follicles become closely crowded together, although never actually fused.

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* Figs. 1–7 show progressive stages in the development of the male reproductive system.

The vasa deferentia *vd* (Fig. 1) run backwards from each end of the horseshoe-shaped band. They are paired, slender ducts lying below the heart and extending back as far as its posterior margin. At this point, each duct bends outwards at right angles, runs between the musculature of the body wall and the carapace, and passes laterally and ventrally behind the luminous organ, to open on the sternum of the eighth thoracic segment near the middle line. The vasa deferentia are slightly dilated immediately behind the external genital apertures *ega* (Fig. 2).

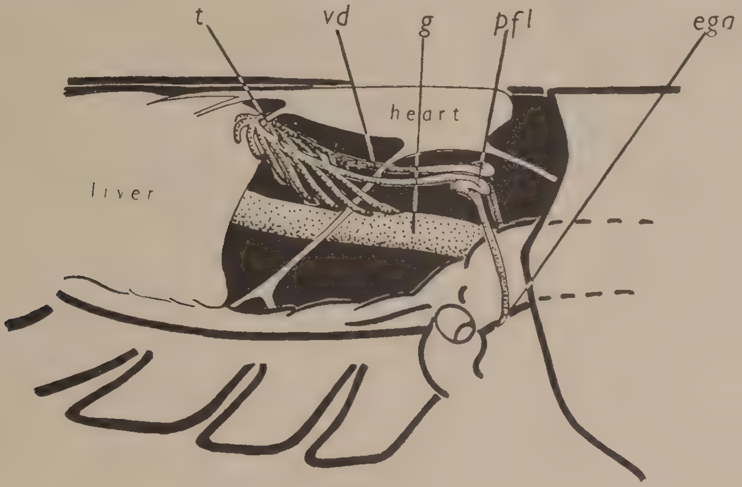


Fig. 2. Dissection to show the development of the male reproductive system. × 15. *ega*, external genital aperture; *g*, gut; *pfl*, posterior flexure; *t*, testis; *vd*, vas deferens.

As can be seen from the diagrams, the heart and some of the main blood vessels[1] are closely associated with the reproductive system. The hepatic artery *ha* runs into the lobes of the liver immediately behind the median anterior testicular follicle (Fig. 1), while the cephalic aorta *ca* and the anterior lateral arteries *ala* branch off immediately in front. The descending aorta *da* passes between the vasa deferentia to the ventral body wall, and the posterior aorta *pa* leaves the heart just above the right angle bend. The intestine is ventral to the reproductive system.

As growth proceeds, the vas deferens becomes slightly swollen in the region of the right angle bend, and a flexure *pfl* appears, so that there is a short anteriorly directed part from which the duct runs outwards and backwards to the external opening (Fig. 2).

[1] The names of the blood vessels are taken from Zimmer's account of the Euphausiacea in Kükenthal and Krumbach's *Handbuch der Zoologie*, vol. III, pt. I, 1926–7.

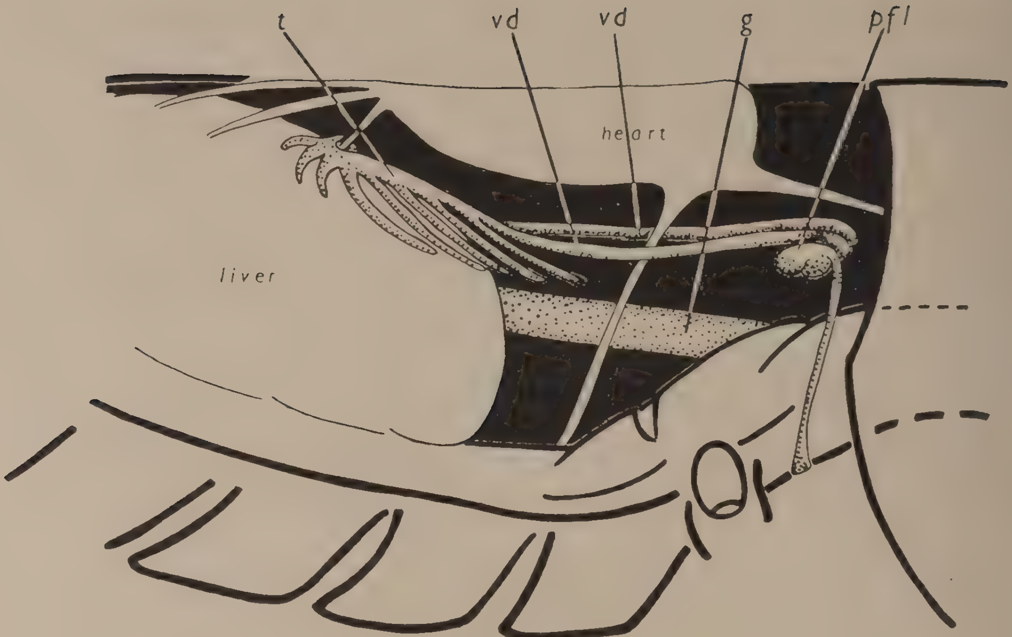

t
vd
vd
g
pfl
heart
liver

Fig. 3. Dissection to show the development of the male reproductive system. × 15. *g*, gut; *pfl*, posterior flexure; *t*, testis; *vd*, vas deferens.

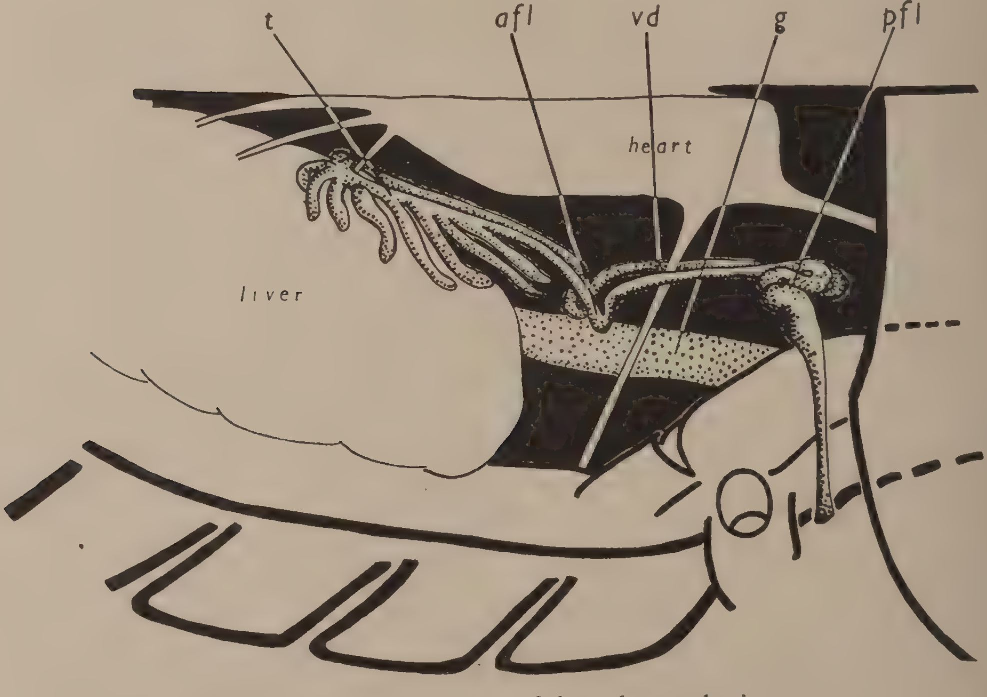

t
afl
vd
g
pfl
heart
liver

Fig. 4. Dissection to show the development of the male reproductive system. × 15. *afl*, anterior flexure; *g*, gut; *pfl*, posterior flexure; *t*, testis; *vd*, vas deferens.

The flexure increases in length and thickness, and in addition a swelling appears on it forming a lateral pocket, anterior to the point at which the duct bends outwards over the ventral musculature (Fig. 3). At the same time, the growth of the liver in a posterior direction alters the position of the testis, so that the latter comes to lie more closely and completely on the lobes of the liver (Figs. 1–7).

A second flexure *afl* (Fig. 4) appears at a short distance behind the junction of the vasa deferentia with the testis, at the point where the vasa deferentia are most widely separated from one another, before they come to lie close together in a median position.

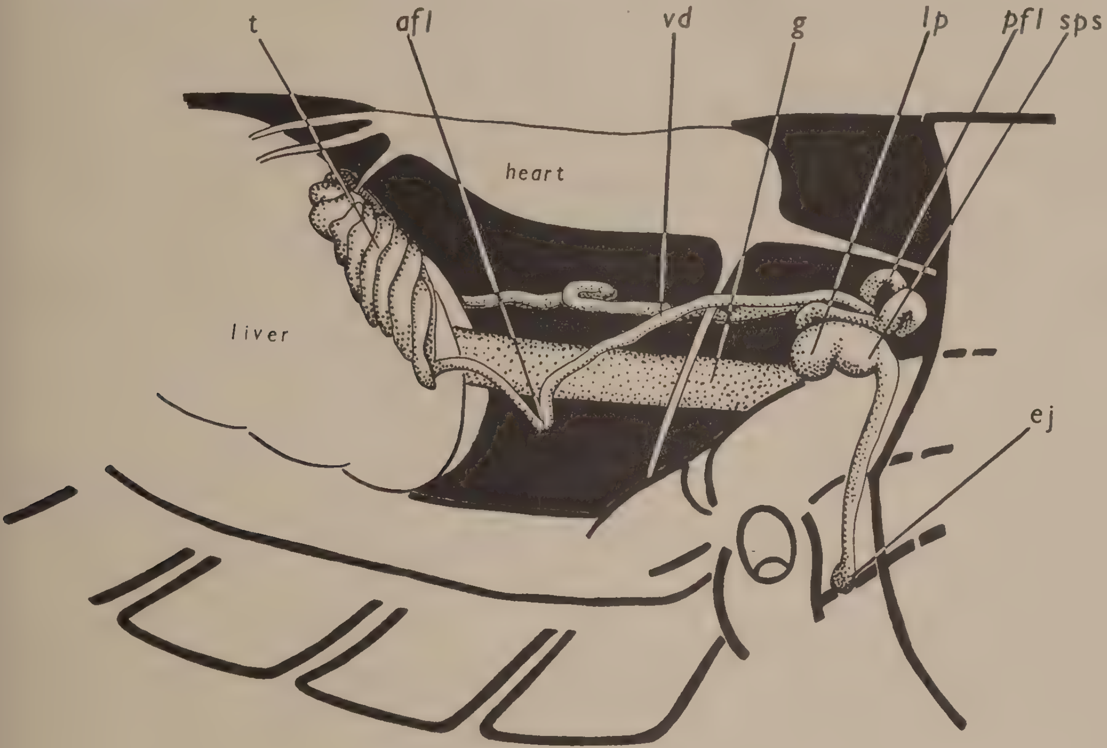


Fig. 5. Dissection to show the development of the male reproductive system. × 15. *afl*, anterior flexure; *ej*, ejaculatory duct; *g*, gut; *lp*, lateral pocket; *pfl*, posterior flexure; *t*, testis; *sps*, spermatophore sac; *vd*, vas deferens.

This anterior flexure is bent first outwards and then inwards again. The vasa deferentia are also more swollen behind the external genital apertures.

The follicles of the testis increase in size until they are closely crowded together, hiding the horseshoe-shaped band. Both the anterior and posterior flexures grow larger, the vasa deferentia begin to show coiling, while the lateral pocket *lp* is more marked (Fig. 5).

Coiling extends gradually over the whole length of the vasa deferentia between the anterior and posterior flexures. At the same time, the walls of the ducts become thickened, especially in the region of the lateral pockets *lp*. At this stage there is often a small mass of chitin in the enlarged part of the ducts *ej* behind the external opening. It is of the same shape as the full-sized spermatophore, but whether it contains active spermatozoa seems doubtful (Fig. 6).

After some further growth, the mature condition is reached (Figs. 7 and 8). The follicles of the testis are often difficult to distinguish separately, because they are very tightly packed together. The horseshoe-shaped band, formerly regarded as part of the vasa deferentia, was shown by Raab (1915) to be filled with germinal tissue even in quite young specimens, and is therefore more correctly considered to be part of the testis.

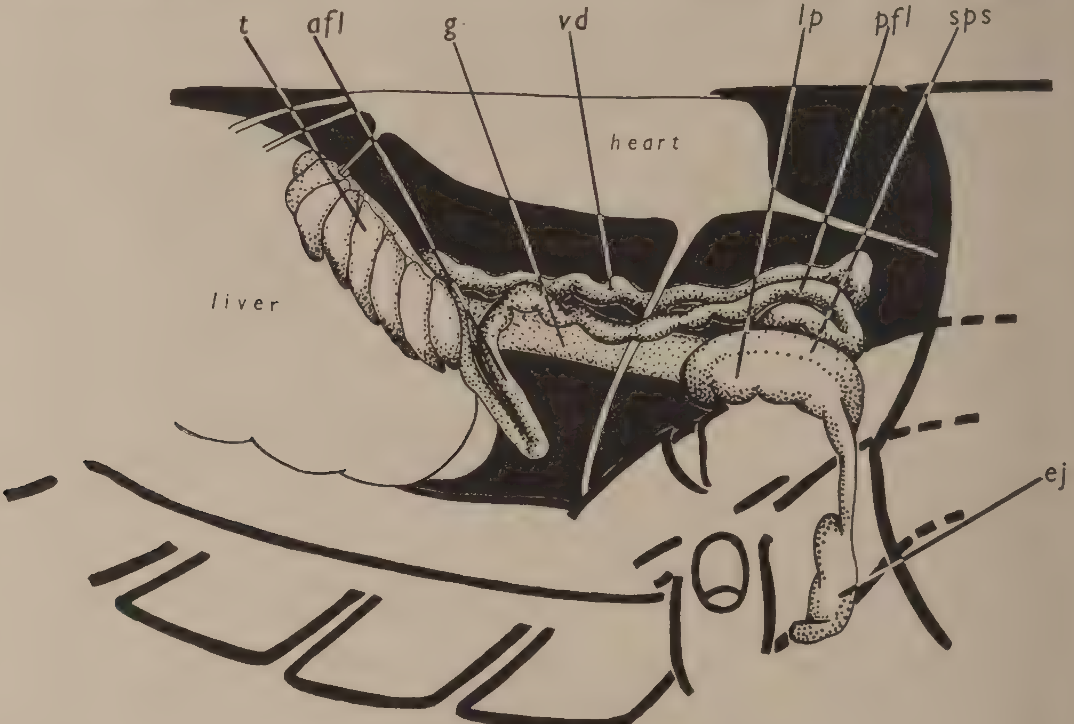
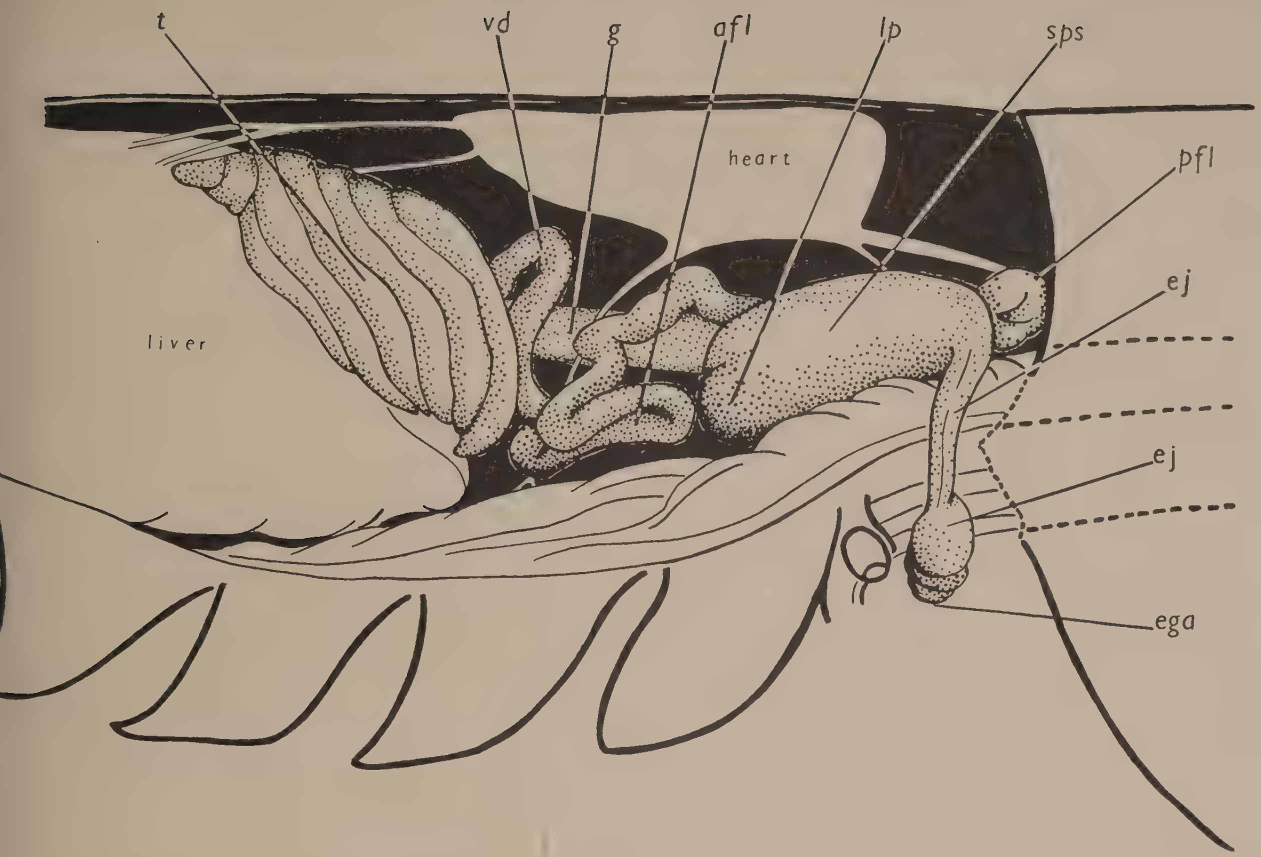


Fig. 6. Dissection to show the development of the male reproductive system. × 15. *afl*, anterior flexure; *ej*, ejaculatory duct; *g*, gut; *lp*, lateral pocket; *pfl*, posterior flexure; *sps*, spermatophore sac; *t*, testis; *vd*, vas deferens.

Raab (1915) determined the histology and function of the various parts of the reproductive system. He found that in the region of the anterior flexure *afl*, the lumen of the vasa deferentia is fairly wide and is lined with flattened cells of pavement epithelium. In mature males it is full of spermatozoa. The lumen is not so wide in the region of the posterior flexure *pfl*, being lined with columnar epithelium and containing, in addition to spermatozoa, a secretion which is the product of the epithelial cells.

Behind the posterior flexure, where the lateral pocket *lp* opens into the duct, the lumen widens again and the epithelium flattens. Chun (1896) called this part of the vas deferens the spermatophore sac *sps* (Figs. 7 and 8), and in mature specimens a spermatophore in process of formation is to be found in each sac. The spermatozoa,


t
vd
g
afl
lp
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heart
pfl
ej
liver
ej
ega

Fig. 7. Dissection to show the mature male reproductive system. Lateral view. × 15. *afl*, anterior flexure; *ega*, external genital aperture; *ej*, ejaculatory duct; *g*, gut; *lp*, lateral pocket; *pfl*, posterior flexure; *sps*, spermatophore sac; *t*, testis; *vd*, vas deferens.

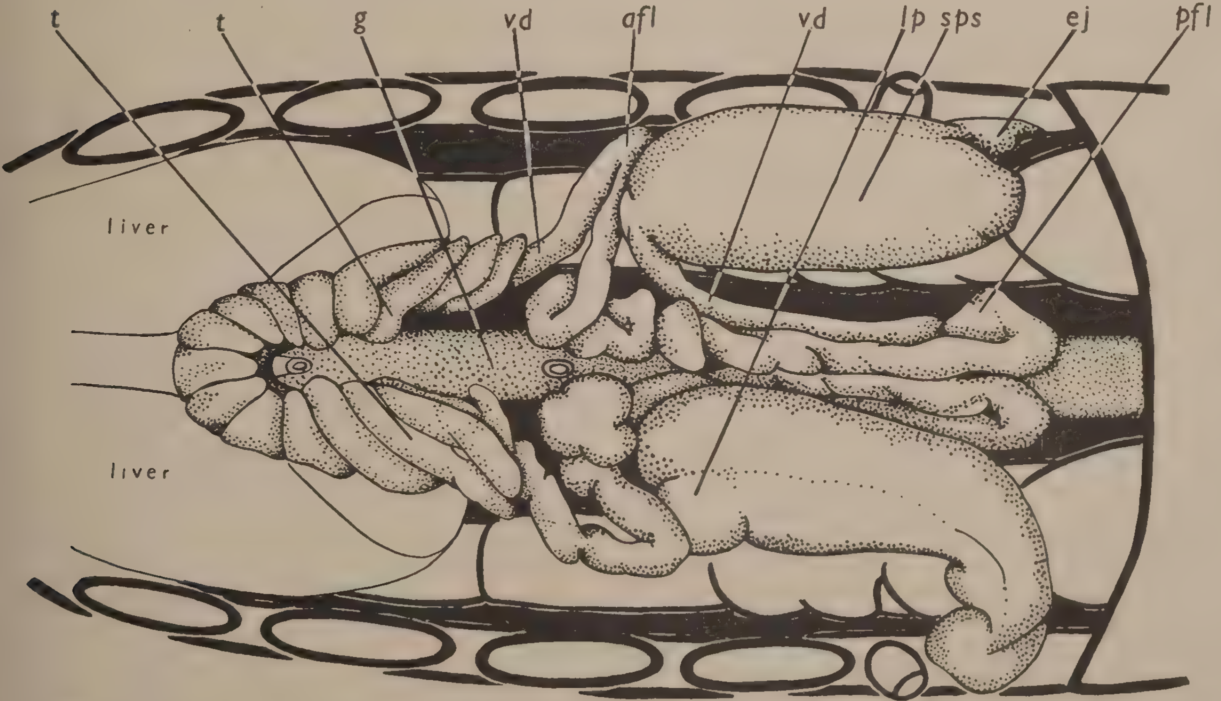

t
t
g
vd
afl
vd
lp
sps
ej
pfl
liver
liver

Fig. 8. Dissection to show the mature male reproductive system. Dorsal view. × 15. *afl*, anterior flexure; *ej*, ejaculatory duct; *g*, gut; *lp*, lateral pocket; *pfl*, posterior flexure; *sps*, spermatophore sac; *t*, testis; *vd*, vas deferens.

oval cells with round or oval nuclei, collect in the spermatophore sac together with a large part of the secretion from the preceding part of the duct. The epithelium of the sac secretes a chitinous cuticle, which encloses this mass in the spermatophore sheath. The spermatophore is flask-shaped and lies in the sac with its head towards the external opening. When fully formed it passes from the sac into the ejaculatory duct *ej*, the muscular part of the vas deferens immediately adjacent to the external genital aperture *ega* (Fig. 7), where it remains until transferred to the female. The lateral pocket *lp* functions as a cement gland, and its secretion adheres to the neck of the spermatophore and serves to fix it on to the ventral surface of the female. In mature males, one spermatophore is to be found in each ejaculatory duct, and another one in each spermatophore sac, ready to take the place of the first after transference has occurred. The first two pleopods in the male are especially modified to effect transference.

DEVELOPMENT OF THE COPULATORY ORGANS

The endopods of the first pair of pleopods show secondary sexual modifications before any differentiation of the second pair has begun.

The endopod is at first quite typical, consisting of a large blade-like setigerous lobe *sl* and a smaller rod-like auxiliary lobe *al* (or appendix interna), which carries a number of small hooks or cincinnuli (Fig. 9). After a time, a blunt oval lobe *p* grows out below the auxiliary lobe: this is the first appearance of the chief copulatory organ, the petasma (Fig. 10).

The petasma *p* soon becomes cleft into two parts, the inner lobe *il* carrying two spines, and the median lobe *ml* carrying one spine (Fig. 11). Growth of these two lobes continues, the two spines on the inner lobe occupying terminal and proximal positions respectively, while the spine on the median lobe becomes lateral by reason of the extension of the tip of this lobe.

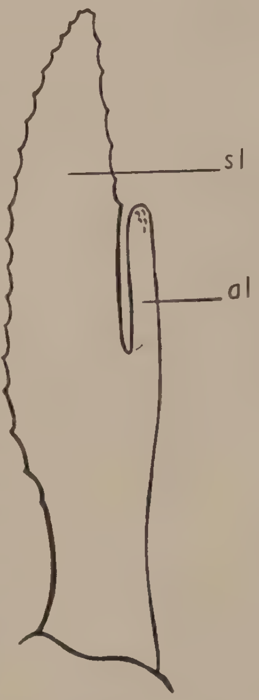


Fig. 9.

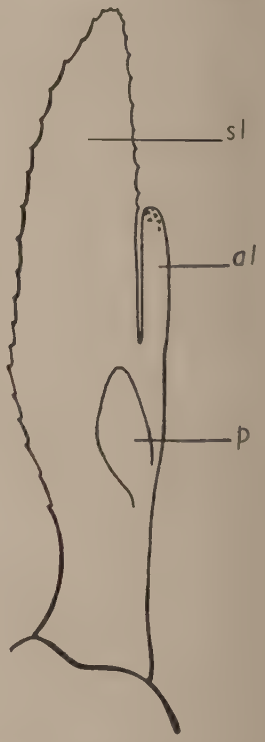


Fig. 10.

Fig. 9. First pleopod, undifferentiated. × 30. *al*, auxiliary lobe; *sl*, setigerous lobe.

Fig. 10. First pleopod. Development of the petasma. × 30. *al*, auxiliary lobe; *p*, petasma; *sl*, setigerous lobe.

A fold, the wing *w*, running parallel to the margin of the setigerous lobe also develops (Fig. 12) and which, as growth continues and the petasma extends further over the surface of the setigerous lobe, curves over the two processes of the inner lobe (Fig. 13). Growth of the median lobe proceeds more rapidly than that of the inner lobe, but the terminal process *pt* of the latter is now so long that it reaches almost to the top of the median lobe (Fig. 14). The proximal process *pp* now begins to broaden at its tip (Fig. 14) and finally shows a leaf-like expansion, while one or two small hooks *pa* develop on the end of the median lobe (Fig. 15).

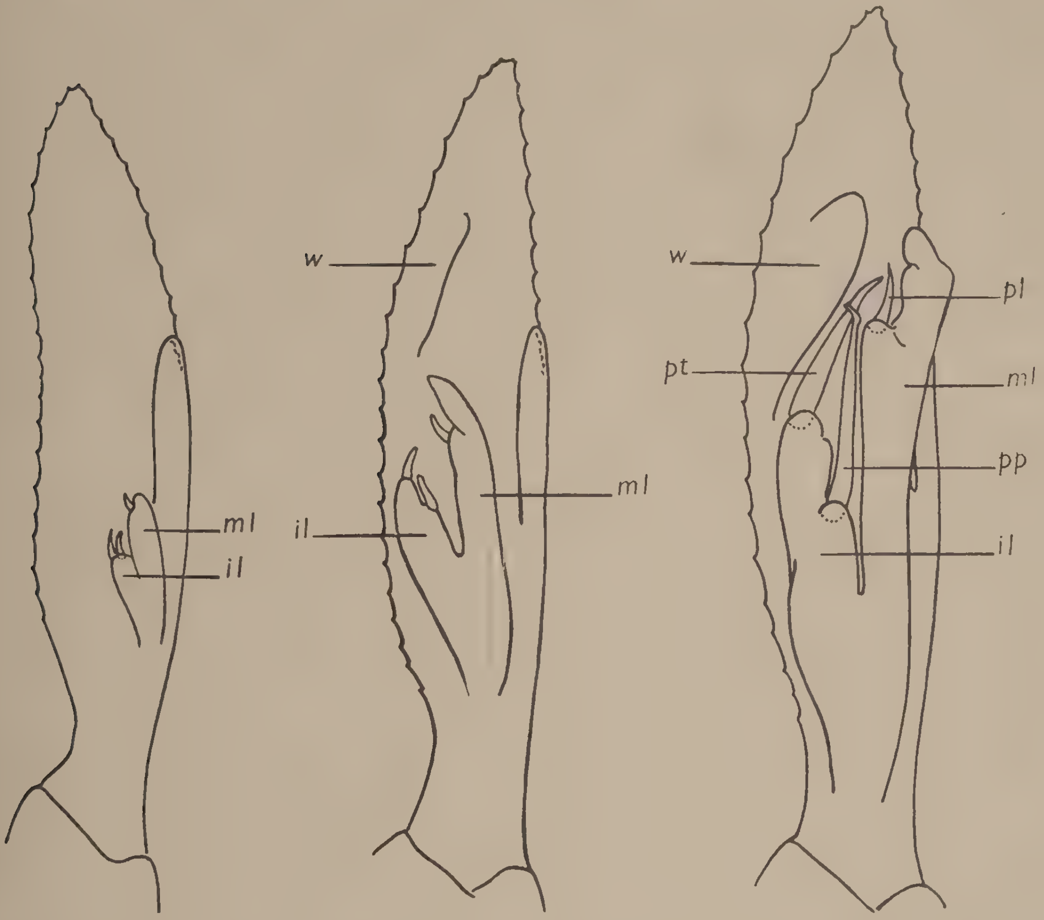


Fig. 11. Fig. 12. Fig. 13.

Fig. 11–13. First pleopod. Development of the petasma. × 30. *il*, inner lobe; *ml*, middle lobe; *pl*, lateral process; *pp*, proximal process; *pt*, terminal process; *w*, wing.

The adult condition has now been reached. This has been fully described by D. D. John (1936) in his paper on "The southern species of the genus *Euphausia*", and he has kindly allowed me to quote his description and to reproduce one of his figures.

When the mature petasma is unrolled (Figs. 16 *a* and *b*) it can be seen that the "proximal part of the terminal process *pt* is bent nearly at a right angle to the distal part, which is about three times as long.... The end of the process tapers and curls forwards; it is not bifid. The distal two-fifths of the proximal process *pp* is bent inwards and carries two membranous expansions, one distally *a*, the greater part of it lying on the hinder end of the axis of the process, one *b* on the foremost side immediately near the bend. The distal end of the former touches the latter. The foremost expansion *b* is striated, that which is distal and for the most part hindermost *a* is not.... [A secondary process] is present in the majority of males, though not in all, as a spine *c* bent forwards over the foremost expansion *b*. It may be as long as that shown in Fig. 30, *d*1, *d*2 [my Fig. 16] or very much smaller, or it may be entirely wanting: of thirty heavily chitinised males examined, it was present in the left petasmas of twenty, absent from those of ten. The lateral process *pl* is curved at the end; it carries no tooth or secondary process. On

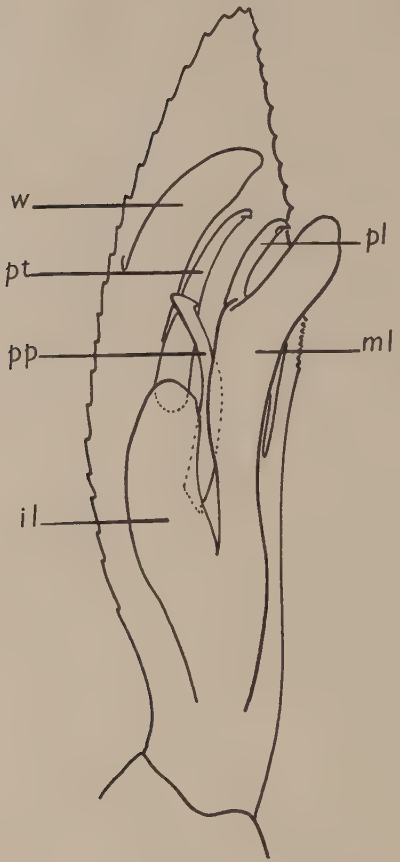


Fig. 14.

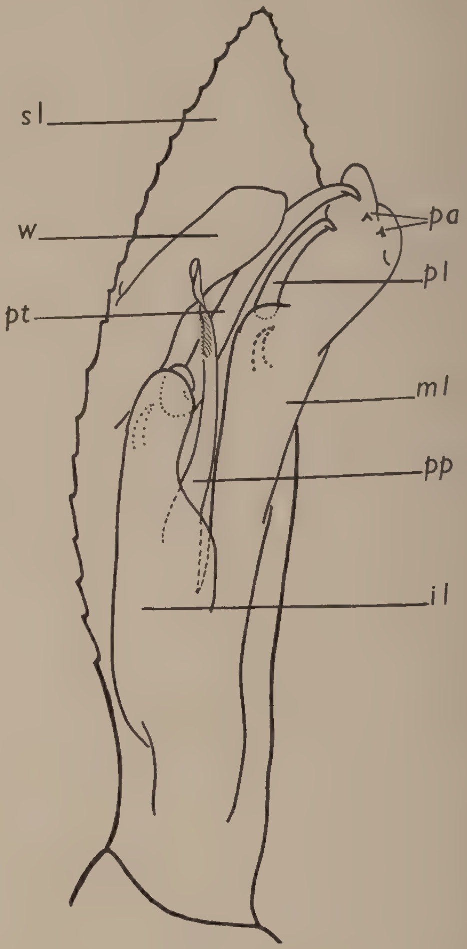


Fig. 15.

Fig. 14. First pleopod. Development of the petasma. × 30. *il*, inner lobe; *ml*, middle lobe; *pl*, lateral lobe; *pp*, proximal process; *pt*, terminal process; *w*, wing.

Fig. 15. First pleopod. Mature form. Left side. × 30. *il*, inner lobe; *ml*, middle lobe; *pa*, additional process; *pl*, lateral lobe; *pp*, proximal process; *pt*, terminal process; *sl*, setigerous lobe; *w*, wing.

the inner or front margin of the median lobe *ml*, beyond the end of the lateral process *pl*, there is always a small additional process *pa*; in one specimen there were two additional processes." A very small spine-shaped process *d* on the inner lobe *il* has been seen in one or two specimens of *E. superba*.

There is nothing that I can add to this account of the adult petasma, except to say that I have not found the secondary process *c* on the membranous expansion *b* of the proximal process as frequently as John did. In fact, in most of the adult males examined by me it was completely absent. It may be developed only when certain conditions occur, or may even be a regional variation.

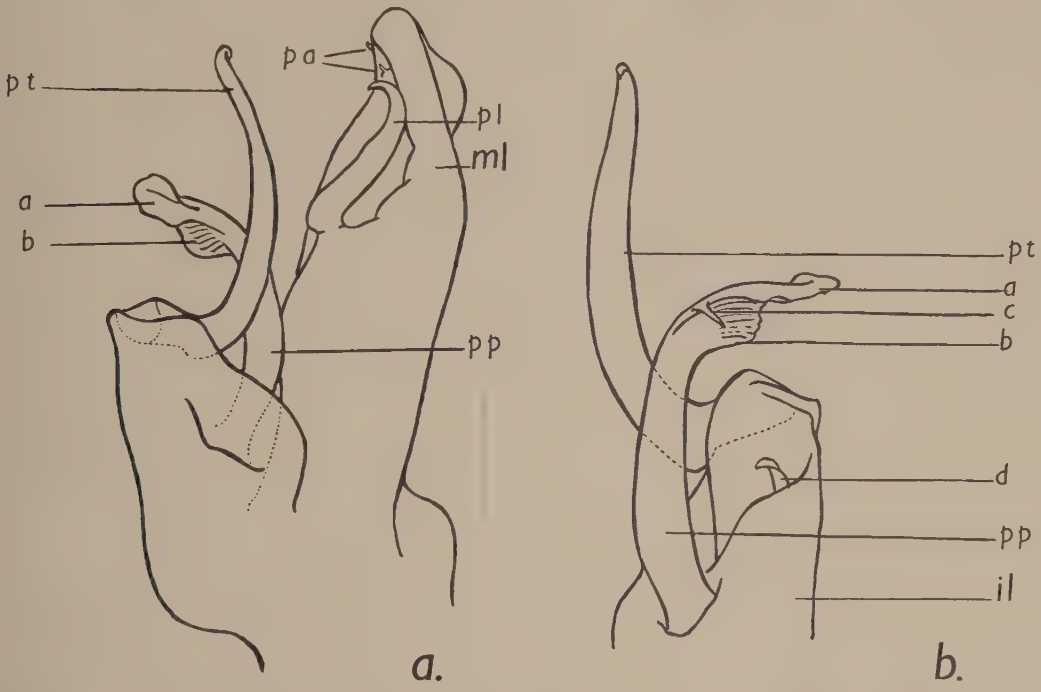


Fig. 16*a*. Mature petasma, inner and middle lobes from behind (reproduced from John's paper). × 30. *a*, distal expansion; *b*, foremost expansion; *ml*, middle lobe; *pa*, additional process; *pl*, lateral lobe; *pp*, proximal process; *pt*, terminal process.

Fig. 16*b*. Terminal and proximal processes from in front. × 30. *c*, spine; *d*, spine-shaped process.

In my observations, two additional processes *pa* occur more frequently on the median lobe than one, and I have also seen from time to time the small spine *d* on the inner lobe. On p. 207 of his report, John draws attention to the fact that processes of a future moult can be displaced, perhaps in fixation, and by penetrating the chitinous coat give a false impression of the presence of an additional process. I have frequently noticed this condition, while examining the developmental stages of the petasma.

The modification of the second pair of pleopods (Fig. 17) proceeds rather differently, and does not begin until the petasma is well established in the first pair. The tip of the auxiliary lobe *al* exhibits a cleft on its outer side (Fig. 18) which grows rapidly and divides

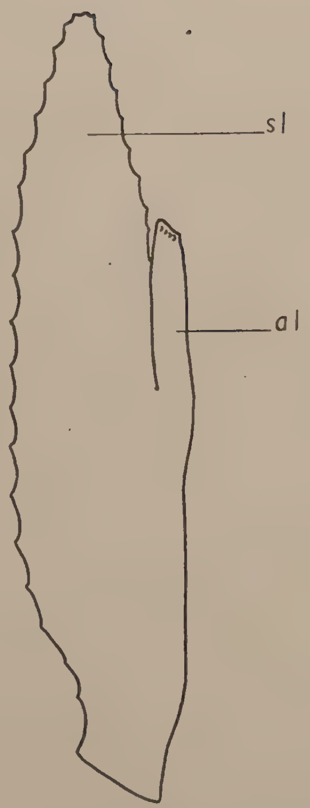


Fig. 17.

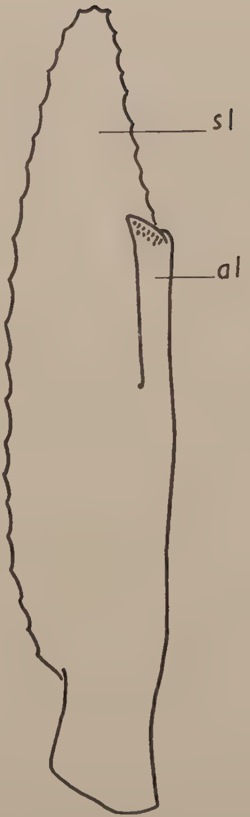


Fig. 18.

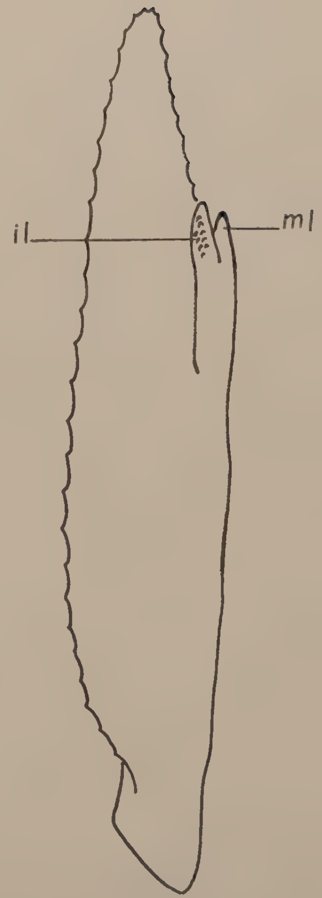


Fig. 19.

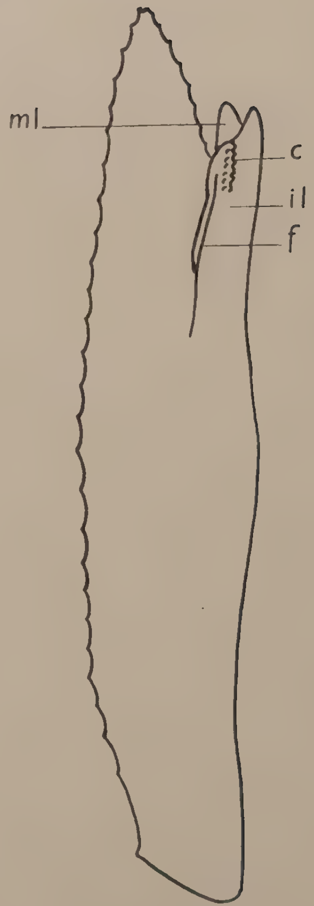


Fig. 20.

Fig. 17. Second pleopod, undifferentiated. × 30. *al*, auxiliary lobe; *sl*, setigerous lobe.
Fig. 18. Second pleopod, modification of the auxiliary lobe. × 30. *al*, auxiliary lobe; *sl*, setigerous lobe.
Fig. 19. Second pleopod, modification of the auxiliary lobe. × 30. *il*, inner lobe; *ml*, middle lobe.
Fig. 20. Second pleopod, modification of the auxiliary lobe. × 30. *c*, cincinnuli; *f*, fold; *il*, inner lobe; *ml*, middle lobe.

the lobe into two parts (Fig. 19). In the adult, these two parts have been called by Zimmer (1913) the inner lobe *il* and the middle lobe *ml*, respectively. The inner lobe carries the cincinnuli.

The auxiliary lobe does not increase in length as modification continues, but it becomes broader and gradually shifts farther towards the tip of the setigerous lobe *sl*. A fold *f* arises on the inner lobe and extends downwards over the surface of the setigerous lobe, beyond the junction of the auxiliary lobe (Fig. 20).

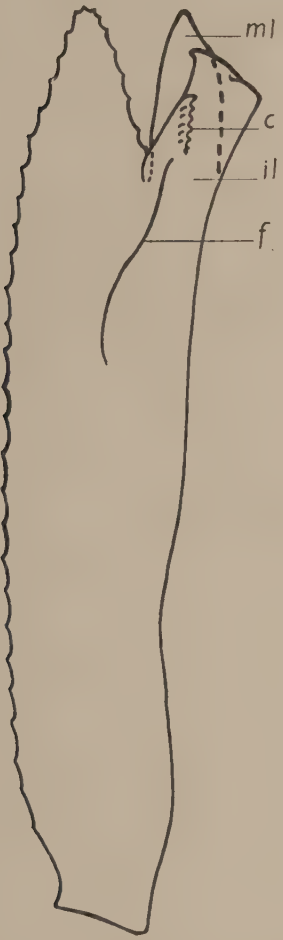


Fig. 21.

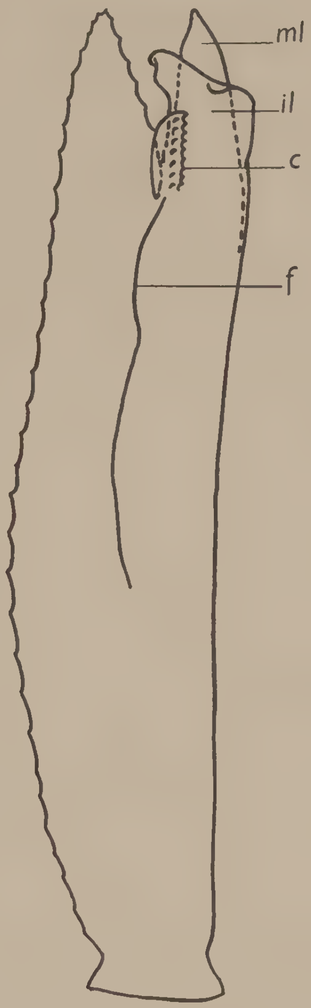


Fig. 22.

Fig. 21. Second pleopod, modification of the auxiliary lobe. × 30. *c*, cincinnuli; *f*, fold; *il*, inner lobe; *ml*, middle lobe.

Fig. 22. Second pleopod, mature form. × 30. *c*, cincinnuli; *f*, fold; *il*, inner lobe; *ml*, middle lobe.

The tip of the inner lobe extends outwards beyond the cincinnuli, and becomes blunt and rather square, while the tip of the middle lobe remains pointed and reaches to the end of the setigerous lobe (Figs. 21 and 22). A wide furrow runs between the inner and middle lobes, the whole structure being now adult and very heavily chitinized.

Both pairs of modified endopods are very markedly setose, but for the sake of clearness no attempt has been made to show this in the figures.

FEMALE REPRODUCTIVE SYSTEM

The smaller female post-larval specimens exhibit no sign of external sexual modifications, but on dissection the rudiments of the reproductive system can be distinguished in specimens 18–20 mm. in length.

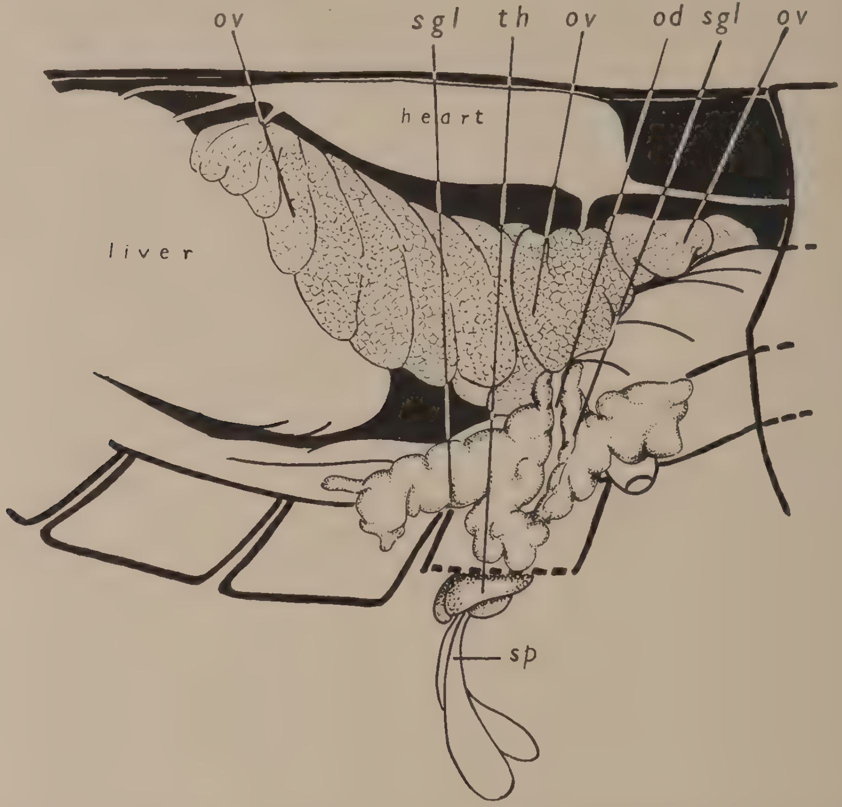


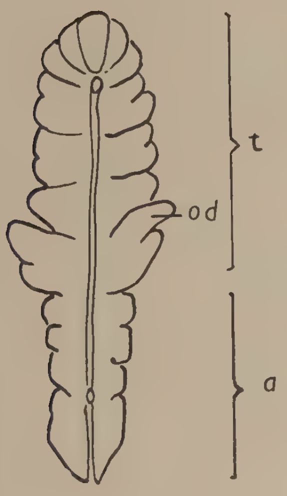
Fig. 23. Dissection to show female reproductive system (half-grown). × 15. *od*, oviduct; *ov*, ovary; *sgl*, shell glands; *sp*, spermatophore; *th*, thelycum. Coxopodite of sixth thoracic leg partly removed to show thelycum.

The ovary lies partly on the liver and below the heart, and partly in the abdomen above the intestine on the abdominal muscles (Fig. 23).

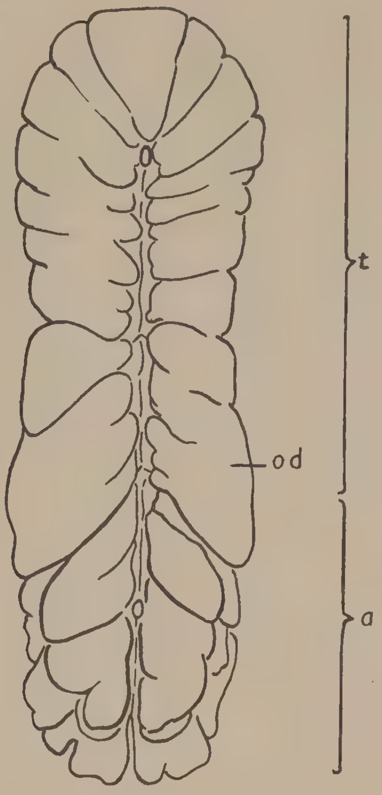
Both Zimmer (1913) and Raab (1915) described the ovary as consisting of a median anterior part joining two lateral lobes, which are contiguous in the middle line. There seems little reason for this differentiation, since these three parts are not clearly defined in either young or old specimens (Figs. 24*a* and *b*).

In the early stages of development, the ovary consists of a number of follicles, arranged in a narrow horseshoe (cf. testis) and forming a saddle-shaped mass. There is generally one terminal follicle and five or six lateral follicles in the thorax, and two or four follicles in the abdomen (Fig. 24*a*).

Raab (1915) noted the lobed appearance of the ovary, and his histological work confirmed that of Chun (1896) on *Stylocheiron* as to the position of the germinal layer, which is situated on the ventral surface of the ovary. It consists of shallow cubical epithelium and shows great nuclear activity.



a



b

Fig. 24*a*. Dorsal view of immature ovary. × 10. *a*, abdominal region; *od*, origin of oviduct; *t*, thoracic region.

Fig. 24*b*. Dorsal view of mature (not gravid) ovary.

The oviducts can clearly be seen in young specimens, as straight tubes passing ventrally from the outside of the ovary, below the posterior end of the heart into the coxopodites of the sixth pair of legs (Fig. 23), to open between the coxopodites and the sternite of the sixth thoracic segment by two large pores.

The ovary is covered with thin connective tissue, by means of which it is suspended in the thorax. As the eggs develop, the connective covering grows too, and finally in mature females the eggs and their covering extend from the heart to the ventral body wall, forward over the liver, and backwards into the abdomen, causing considerable expansion of the cephalothorax, the primitive saddle-shape of the ovary being lost (Fig. 24*b*).

The growth of the ovary is a continuous one, the eggs increasing in size and number until they reach an average diameter of 0·66 mm. and a total number of between 11,000 and 11,500. They become arranged in diagonal rows, extending from the dorsal to the ventral surface. Just before laying, the eggs are so tightly packed that they take on a pentagonal or hexagonal shape towards the external surface and are roughly conical on the inner side.

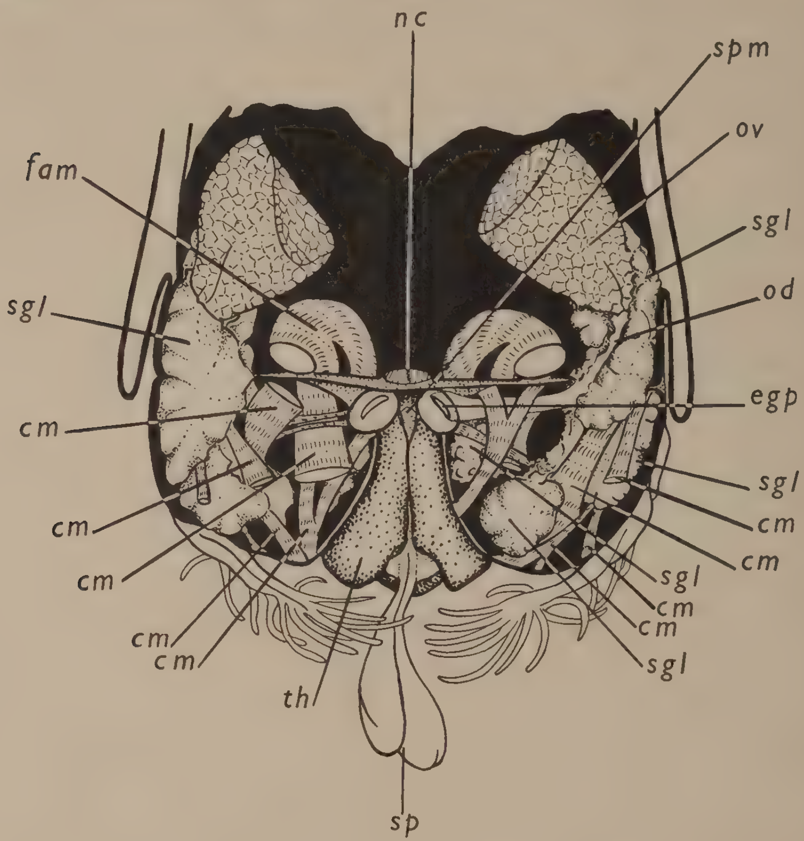


Fig. 25. Dissection to show the female reproductive system in a mature (not gravid) specimen (anterior view). × 15. *cm*, coxal muscle; *egp*, external genital aperture; *fam*, flexor abdominalis muscle; *nc*, nerve cord; *od*, oviduct; *ov*, ovary; *sgl*, shell gland; *sp*, spermatophore; *spm*, sperm mass; *th*, thelycum. Deeper dissection shown on right side of diagram.

Raab (1915) found that the eggs when first detached from the germinal layer had fine granular cytoplasm and a relatively large nucleus. As the eggs mature, the cytoplasm becomes coarsely granular, as more yolk material accumulates. The full-grown eggs are full of yolk.

At the same time there develops round the oviducts a series of diffuse glands, consisting of actively secretory cells, which according to Raab produce the egg capsules.

These glands *sgl* (Plates II–V and Figs. 23 and 25) surround the oviducts *od* (Fig. 23) in their course through the thoracic cavity and extend into the coxopodites of the last four pairs of thoracic legs, including the last two vestigial pairs seven and eight (Fig. 25). They lie between the gills corresponding to these appendages, below the body wall and the large flexor abdominalis muscles *fam*, and extend under the ventral nerve-cord, in the region of the genital pores and posterior to them (Fig. 25).

The oviducts can be traced through the gland masses both by dissection and by the examination of serial sections. Figs. 23 and 25 represent dissections to show their relation to the other parts of the reproductive system, and Plates II–V are photomicrographs of transverse and longitudinal serial sections through the thorax of an adult female. At the point at which the oviducts leave the ovaries (Plate II, figs. 3 and 4), they are fairly thick-walled with a narrow lumen, but, on reaching the coxopodites of the legs, they widen to form a thin-walled atrium into which the secretion of the glands appears to be poured, to surround the eggs before they are laid (Plate III, figs. 2, 3 and 4).

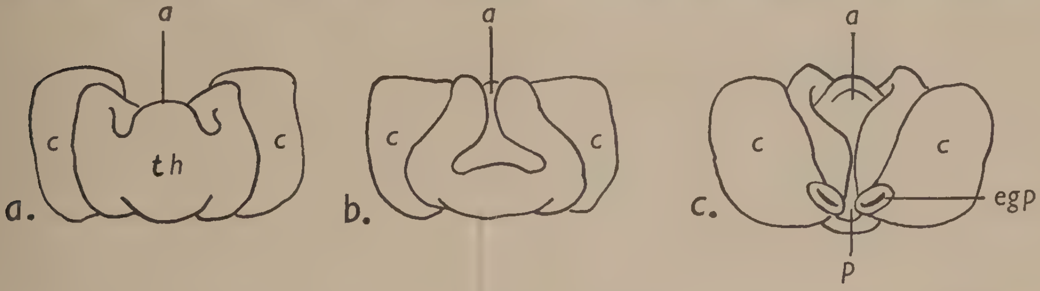


Fig. 26. Three views of the thelycum. ***a***, ventral; ***b***, anterior; ***c***, dorsal. *a*, anterior opening; *c*, coxopodite of sixth leg; *egp*, external genital aperture; *p*, posterior opening.

It seems probable that the great flexor abdominalis muscles *fam*, which run ventrally in the thorax and abdomen, and which increase markedly in size in the region of the last thoracic leg, assist in the expulsion of the eggs (Fig. 25). The coxal muscles *cm* may also operate in the same way (Fig. 25 and Plates II–V).

The external genital pores *egp* (Fig. 25) are transverse slits surrounded by thick lips, and they open into the narrow space between the coxopodites and the ventral body wall (Plate IV, fig. 1 and Plate V, figs. 1, 3 and 4). Sars (1885) and Chun (1896) described the genital pores in *Euphausia* and *Stylocheiron* as being unpaired apertures on the ventral surface of the sixth thoracic segment. Zimmer (1913) found them on the basal joint of the sixth pair of thoracic legs. Raab (1915), working on *Meganyctiphanes* and *Euphausia krohnii*, states that they do not lie on the basal joints, but next to two plates (thelycum) connected to the legs close to the middle line. It will be seen from Fig. 25 and Plates II–V that in *E. superba* they lie on the coxopodites.

Immediately between the genital pores *egp* is the posterior opening *p* of the thelycum *th* (Fig. 26*c*), a pouch formed partly by two wing-like expansions of the coxopodites and partly by an outgrowth from the sternal wall (Plate V, fig. 3). These three plates are fused posteriorly and ventrally, but are wide open anteriorly forming the mouth of the pouch (Fig. 26 *a–c*). Anteriorly, directly below the ventral body wall of the animal, the two coxal plates remain unfused in the middle line, forming an open groove, which runs from the wide mouth of the thelycum *a* to its posterior opening *p* between the genital pores, and which in Fig. 23 is closed by the sperm mass *spm*.

Zimmer (1913) described the thelycum as being derived entirely from outgrowths from the sternum, but the view of Raab (1915), that both the sternum and the coxopodites contribute to its formation, is confirmed in the present results, by examination of transverse and longitudinal serial sections.

FERTILIZATION

Fertilization must be external. The spermatozoa, which are very characteristic oval cells with large nuclei, have never been seen within the body of the female, although Zimmer (1913) described them as penetrating into the thorax. It is clear from his account, as Raab (1915) pointed out, that he mistook the system of diffuse shell glands *sgl* for sperm masses. In all the fertilized females examined during the course of the present investigation, the sperm mass was always confined to the thelycum. The specimens selected for sectioning also carried spermatophores, the contents of which could be clearly seen in the same position (cf. Plate V, figs. 1 and 3) and were never found to have penetrated within the body.

When transference of spermatophores is about to take place, the first two pairs of pleopods of the male, which are specially modified for the purpose, are extended forwards under the thorax. The spermatophores are expelled from the ejaculatory duct and are caught by the pleopods, which transfer them to the thelycum. This operation must be a rapid one, for although male specimens have been obtained with spermatophores extruding from the genital pores, they have never been seen holding them in the pleopods.

Zimmer gives a detailed account of this transference and Raab agrees with it. If the first pair of pleopods is bent forward under the thorax, the modified endopodites do not lie under the genital pores, and could not therefore take up the spermatophores when they are extruded. Further, all the special hooks etc. are on the under side of the endopodite, away from the ventral surface of the animal. The second pair of pleopods, however, if extended forward, coincides with the genital openings, the furrows on the endopodites being turned towards the ventral surface of the body. They are thus in a position to receive the spermatophores. The first pair of pleopods would be in the way, and therefore they are probably bent out laterally during the process.

According to Zimmer, fertilization takes place with the animals lying abdomen to abdomen. In this position, however, the furrows on the second pair of pleopods are opposed to the ventral surface of the female, whereas the organ on the first pair is turned towards her. The spermatophores are evidently passed from the second to the first pair of pleopods, which then fix them into the thelycum of the female, who must be firmly held during this complicated proceeding. Zimmer states that the elasticity of the parts may be sufficient to bring about transfer, but that the musculature alone cannot be effective. It is difficult to understand why he made this statement. The muscular system in *E. superba* is well developed, both in the body and in the appendages, and there is no anatomical evidence to show that the animal is not capable of the sustained muscular effort necessary to effect fertilization. The whole problem is one which can only be solved by observation of living material, but examination of well-preserved specimens confirms Zimmer's suggestions, in the main, as to the method of the transference of the spermatophores.

The spermatophores are held in the thelycum by a chitinous cement substance adhering to their necks, and secreted by the lateral pockets of the spermatophore sacs in sufficient quantity to plug the mouth of the thelycum. The spermatozoa *spm* (Fig. 25) form a white mass in the wider end of the spermatophores when transference has just taken place, but very soon they penetrate up the narrow necks into the cavity of the thelycum itself, filling it completely and extending right up to the posterior opening, next to the female genital pores *egp* (Fig. 25 and Plate V, fig. 3). This penetration is effected by the action of a fluid contained in the spermatophores together with the spermatozoa, and which is secreted by the cell lining of the vasa deferentia in the region of the posterior flexure (see p. 334). This fluid expands, according to Raab, and pushes the sperm mass *spm* before it out of the spermatophore.

Koltzoff (1906) described a similar process in some Decapoda, the spermatophores of which contain a fluid, which swells so prodigiously that it ruptures the chitinous sheath, and shoots the sperm through the egg membrane, thus bringing about fertilization. He called this substance "Explosionsstoff".

The passage of the spermatozoa into the cavity of the thelycum must be rapid, for it is much more usual to find the spermatophores empty and the thelycum full than vice versa, although specimens showing the latter condition occur sometimes in a big catch.

Copulation generally occurs when the eggs have only reached a quarter or a third of their diameter when ripe. The spermatozoa must therefore retain their potency for some time. Normally, two spermatophores are inserted into the thelycum, but any number up to seven has been seen. In those specimens where copulation has occurred more than once, the spermatophores often show all stages between empty and full, indicating that they were affixed at successive intervals of time, and that possibly all of the spermatozoa are unable to penetrate at once into the thelycum, as its capacity is limited.

As the eggs are laid, they come into contact with the sperm mass (Fig. 25 and Plate V, fig. 3), and fertilization is effected. Andrews (1904), in a detailed account of the breeding habits of the American crayfish, writes as follows: "As the eggs are laid they probably pass over the annulus [cf. thelycum in *Euphausia*] and a relatively small amount of sperm might fertilize all of them, if it came out of the sperm plug in time. Before laying the annulus is covered with glair and possibly this may act to bring the sperms out, as well as to protect them from the water....Some osmotic factor may be here concerned in bringing out the sperm. Other means of getting the sperm out of the waxy tube, that we have called the sperm plug, and from the interior of the annulus might be the pressure that the sternal plate between the fifth legs may exert on the annulus when the legs are forced forwards, as seemed to be the case about the time of laying."

In *E. superba*, it seems likely that owing to the close proximity of the genital pores to the free end of the sperm mass (Fig. 25), the pressure due to the extrusion of the eggs will be sufficient to liberate the sperms at the same time from the posterior opening of the thelycum, and thus bring about fertilization. The shell membrane is probably still soft and glutinous, and will therefore allow the passage of the sperms through it.

Meyer (1934) found that in *Crangon vulgaris* the shell membrane remained soft for some time after laying, the hardening process being a gradual one.

In spite of the large number of eggs (11,230 and 11,407 were counted from the ovaries of two gravid females respectively), the process of laying is evidently a rapid one. On two occasions, females with greatly distended carapaces and carrying spermatophores were placed for observation in the aquarium on board the R.R.S. 'Discovery II'; these spawned overnight, and the following morning eggs were found in the water. One of the females was dissected and "many eggs were found in the ovary, floating in a milky fluid, which appeared to consist of an emulsion of tiny oil globules. The eggs were the same size as those found in the aquarium", that is 0·6 mm. in diameter. Spawning in this instance was clearly incomplete, and this was probably due to the fact that, normally, gravid females occur at depths of 250 m. and more, where perhaps the increased pressure of the water assists in the liberation of the eggs. The eggs failed to develop in the aquarium, because the external conditions were not suitable.

After the eggs have been laid, the ovary resumes its primitive saddle shape, and the shell glands are still much in evidence, extending up the oviduct for some distance, as well as remaining in the coxopodites of the legs.

SUMMARY

1. Dissection shows that both male and female reproductive systems are developed before any external sexual characters appear. The sex of each specimen can be determined in this way.

2. A series of stages in the development of the male and female systems was obtained.

3. Modification of the first pair of pleopods begins before the second pair shows any sign of differentiation.

4. The course of the oviducts through the shell glands was traced by means of serial sections as well as by dissection.

5. Transference of spermatophores occurs in the first place before the female is gravid.

6. The spermatozoa retain their potency for some time.

7. Fertilization is external, occurring when the eggs are laid.

8. Spawning takes place rapidly, probably at depths of 200 m. and below.

After I had begun this investigation, a paper by Ruud (1932) appeared on the "Biology of Southern Euphausiidae", in which Ruud drew attention to the fact that the "external sexual characters do not tell us anything about the *degree of maturity* at which the animal has arrived. This must be ascertained by examining the internal organs, the ovary and the testis." A discussion of his results belongs more appropriately to a second paper now in preparation to which this is the introduction, but I have frequently referred to his work and wish to make full acknowledgement here. I was more fortunate than he in having access to larger collections of material, and consequently could carry my anatomical investigations farther.

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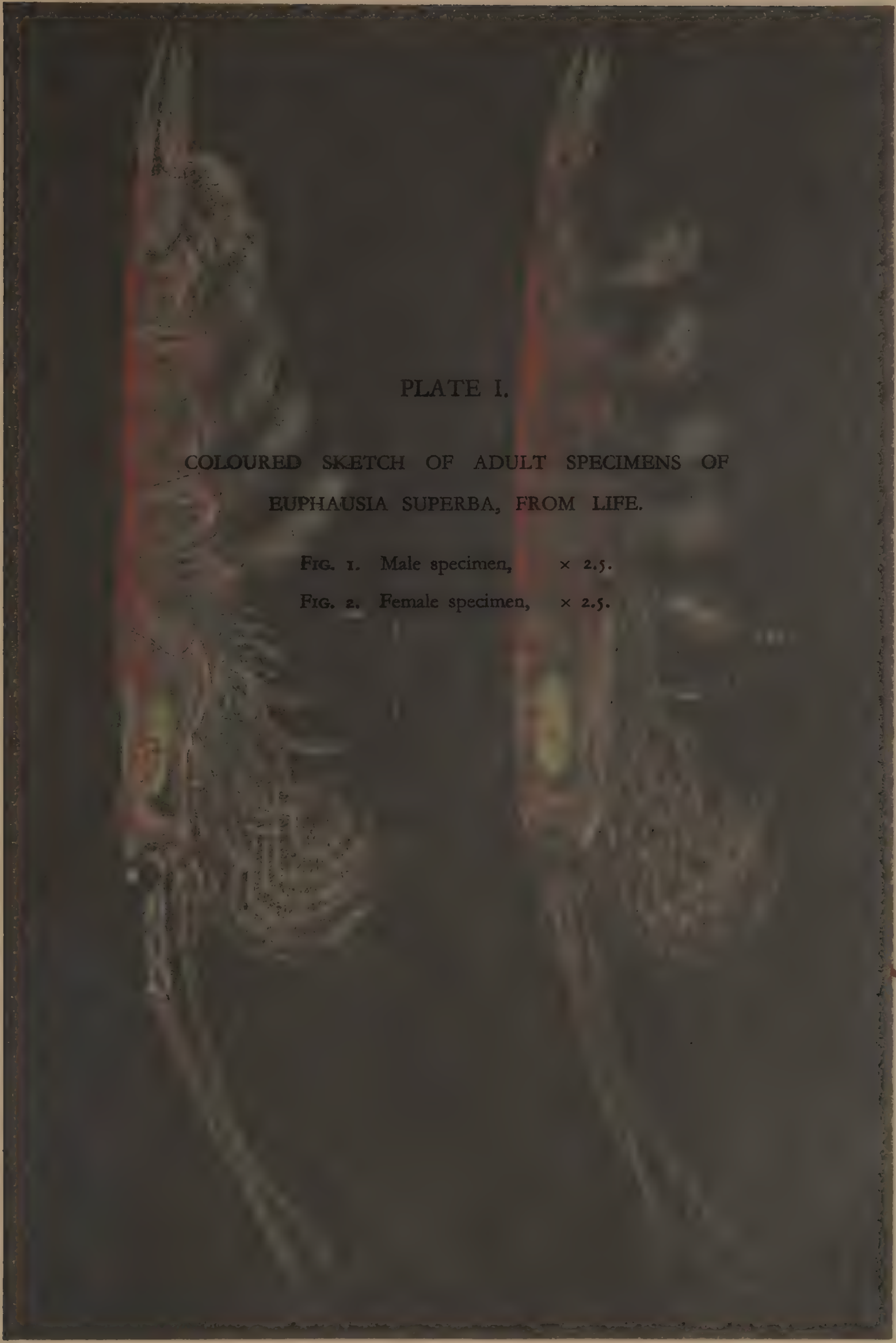
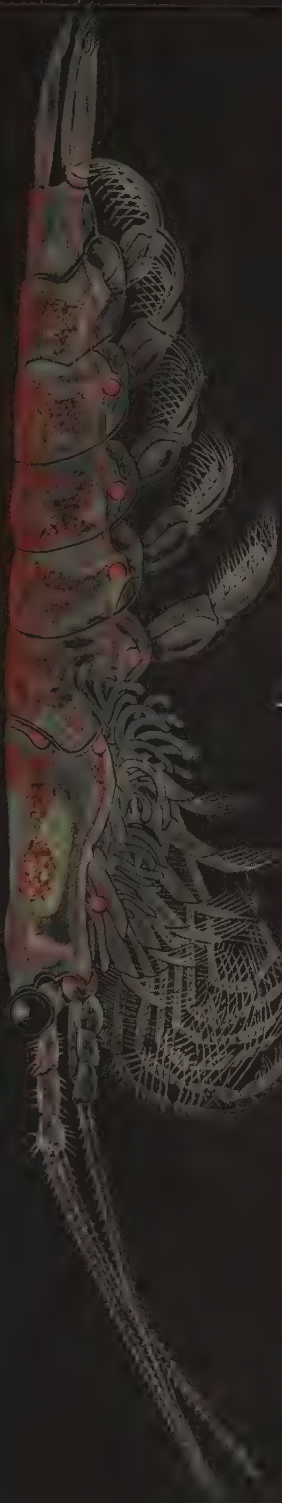


PLATE I.

COLOURED SKETCH OF ADULT SPECIMENS OF EUPHAUSIA SUPERBA, FROM LIFE.

FIG. 1. Male specimen, × 2.5.

FIG. 2. Female specimen, × 2.5.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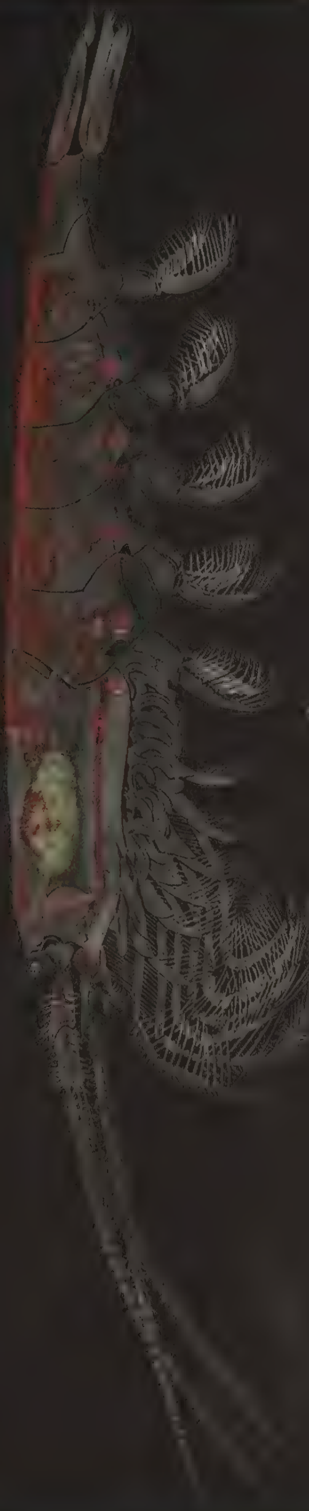
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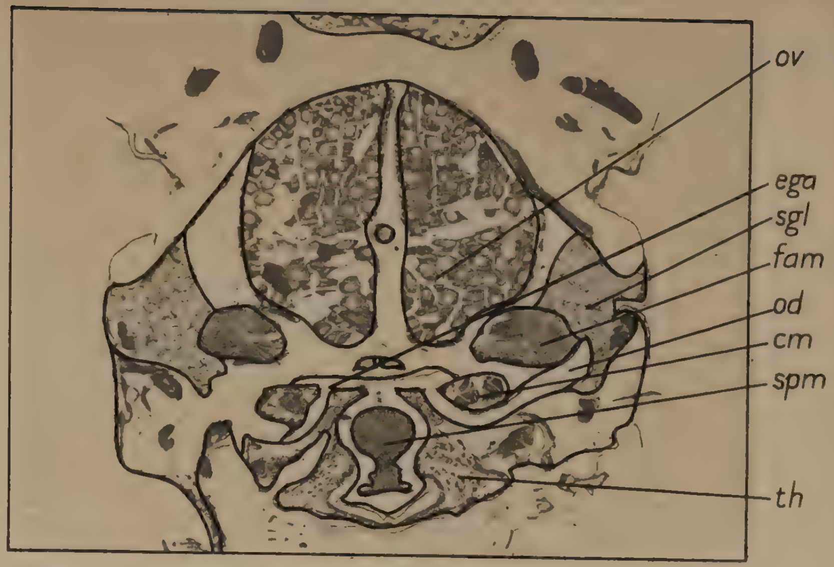
ov
ega
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od
cm
spm
th

FIG. 1. Transverse section through ovary, sperm mass and thelycum. (× 34) *cm*, coxal muscle; *ega*, external genital aperture; *fam*, flexor abdominalis muscle; *od*, oviduct; *ov*, ovary; *sgl*, shell gland; *spm*, sperm mass; *th*, thelycum.

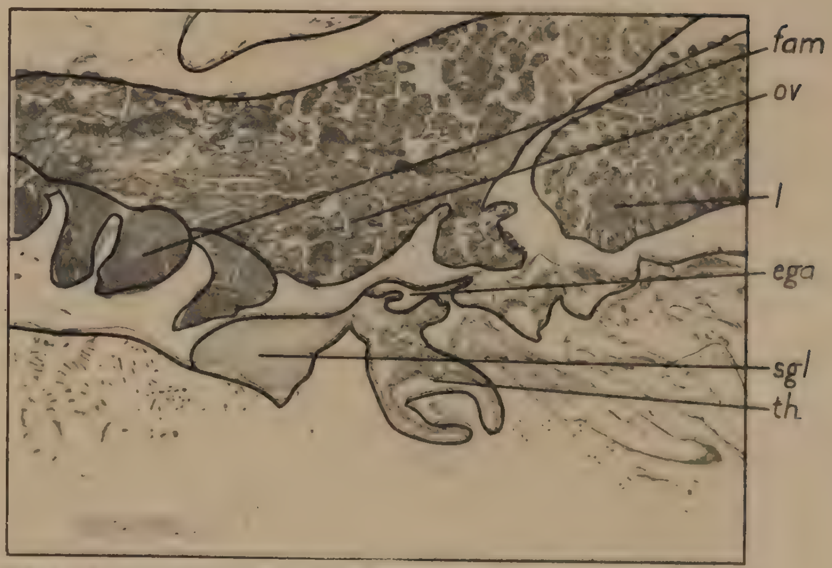
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FIG. 2. Longitudinal section through ovary, liver and thelycum. (× 34) *l*, liver.

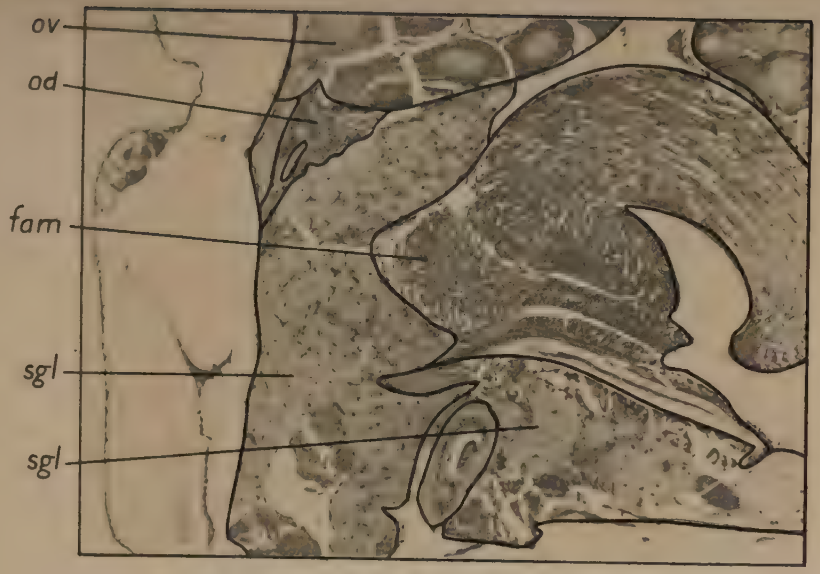
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FIG. 3. Transverse section showing the oviduct leaving the ovary. (× 53)

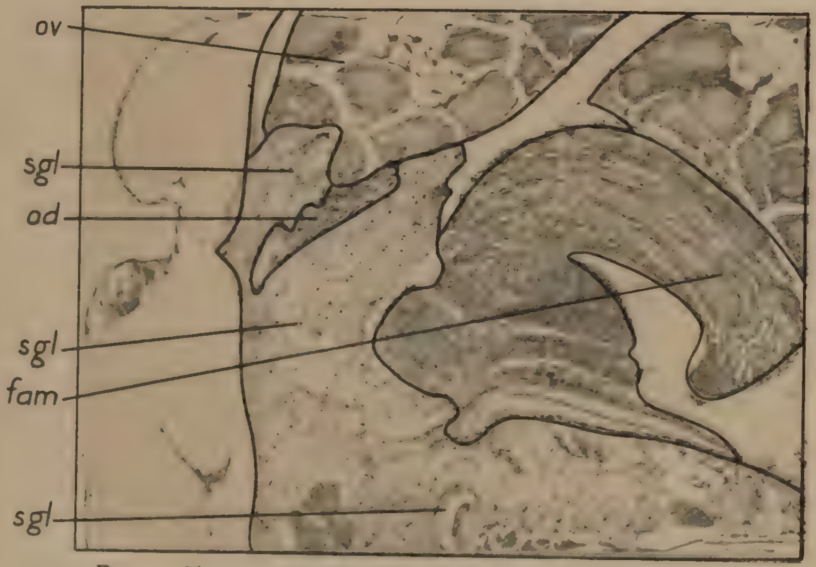
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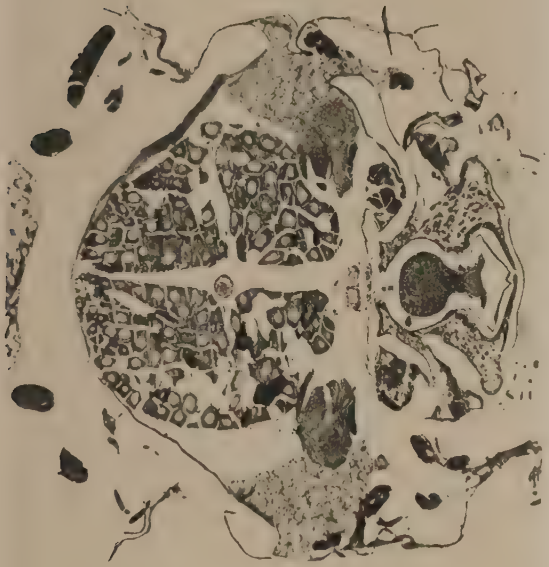
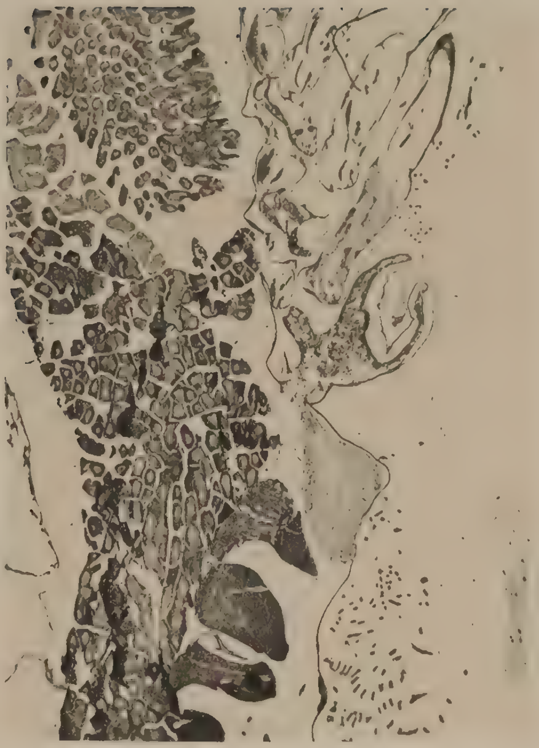
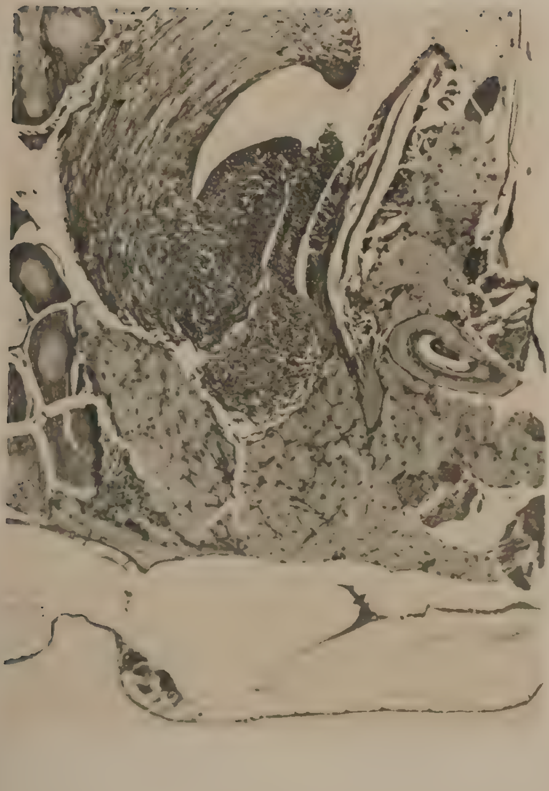
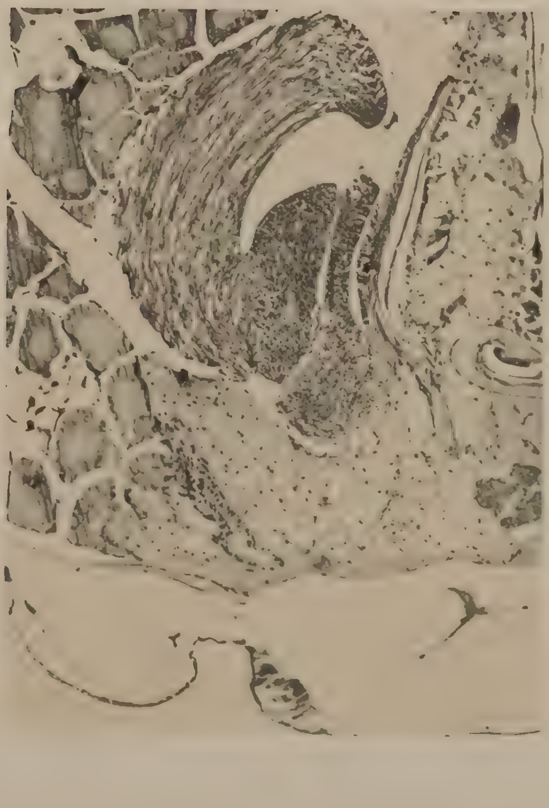
FIG. 4. Transverse section showing the course of the oviduct from the ovary through the shell gland. (× 53)

Photomicrographs of sections through adult female specimens of EUPHAUSIA SUPERBA.









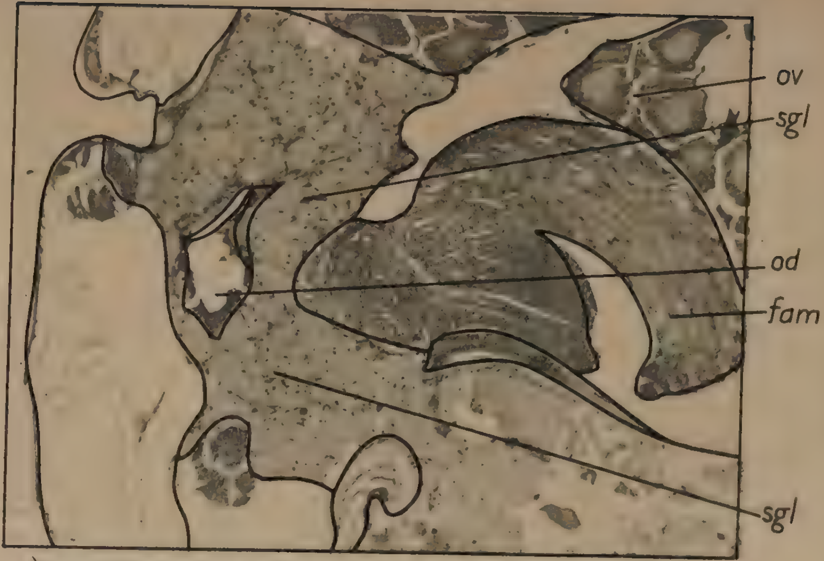


FIG. 1. Transverse section through ovary, etc., showing oviduct surrounded by shell gland. *fam*, flexor abdominalis muscle; *od*, oviduct; *ov*, ovary; *sgl*, shell gland.

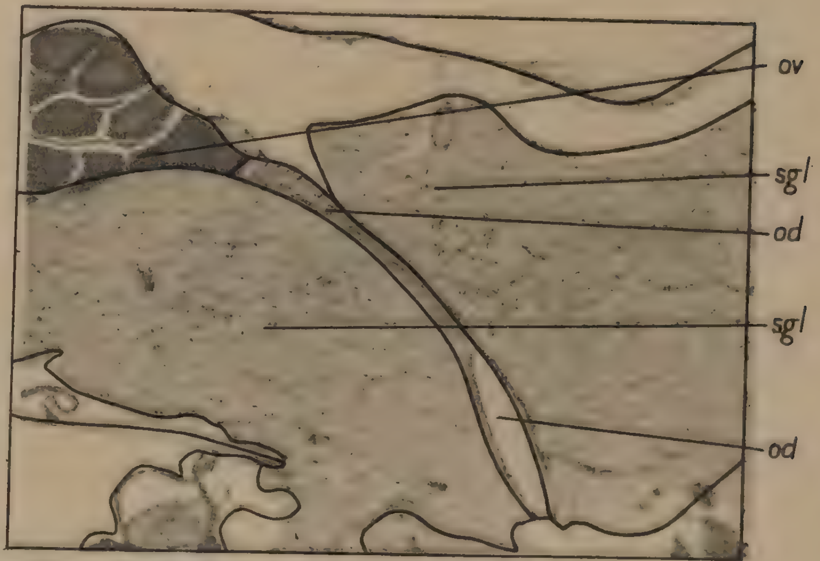


FIG. 2. Longitudinal section showing the course of the oviduct from the ovary through the shell gland.

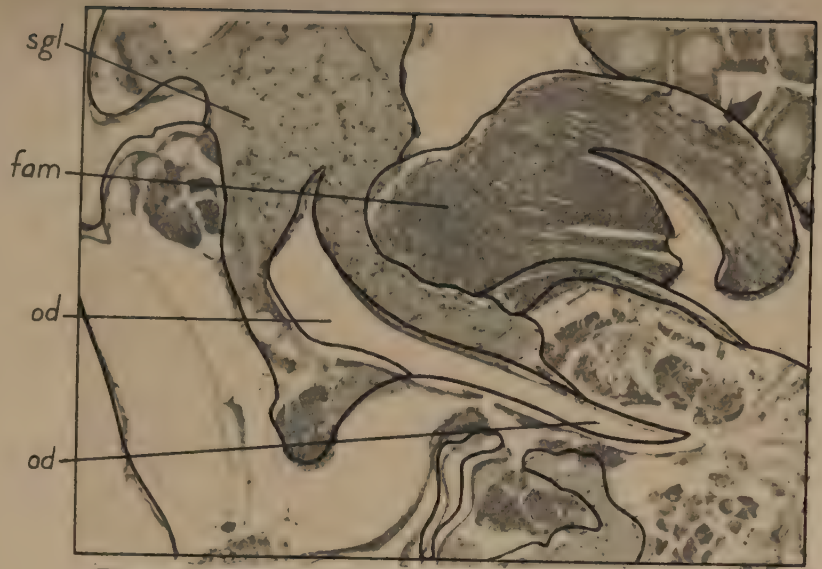


FIG. 3. Transverse section showing the course of the oviduct into the coxa of the sixth leg.

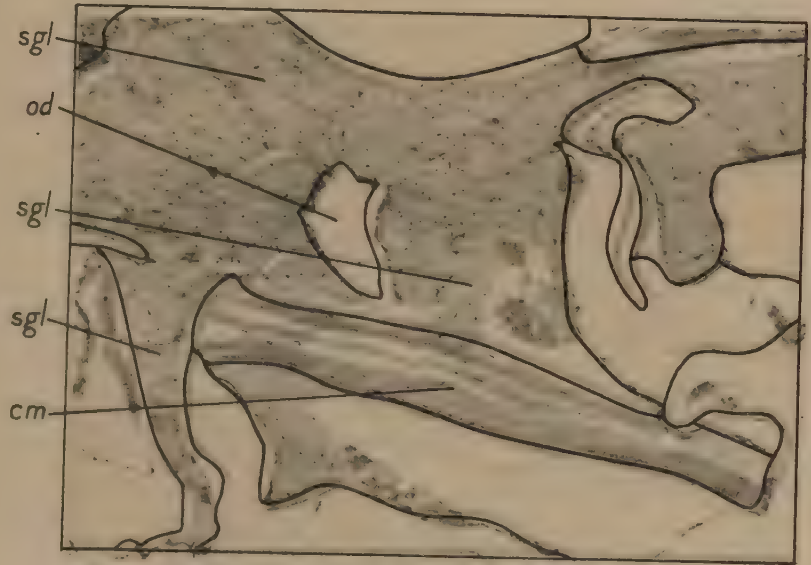


FIG. 4. Longitudinal section showing the course of the oviduct into the coxa of the sixth leg. *cm*, coxal muscle.

Photomicrographs (× 53) of sections through adult female specimens of EUPHAUSIA SUPERBA.

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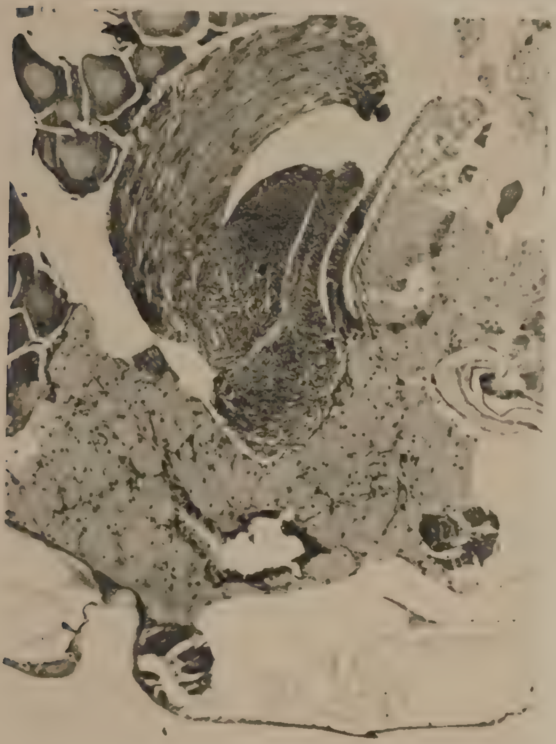
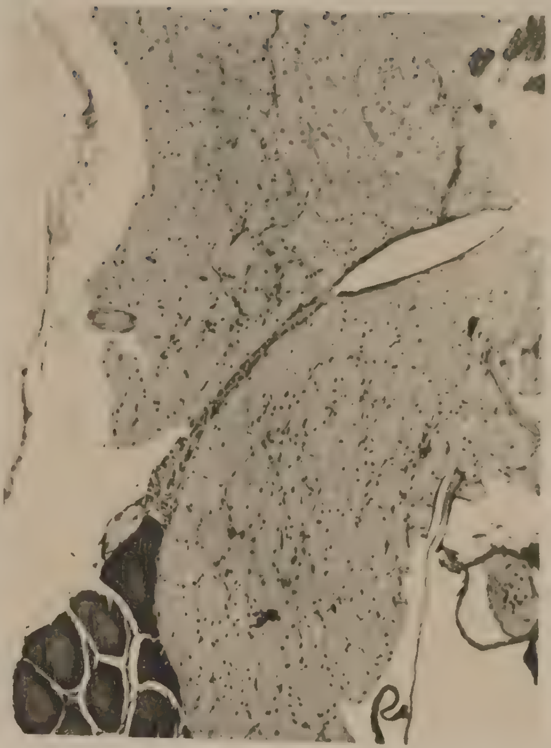
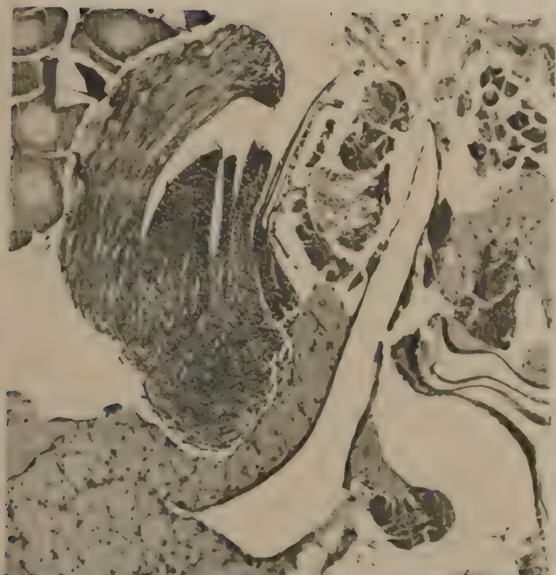
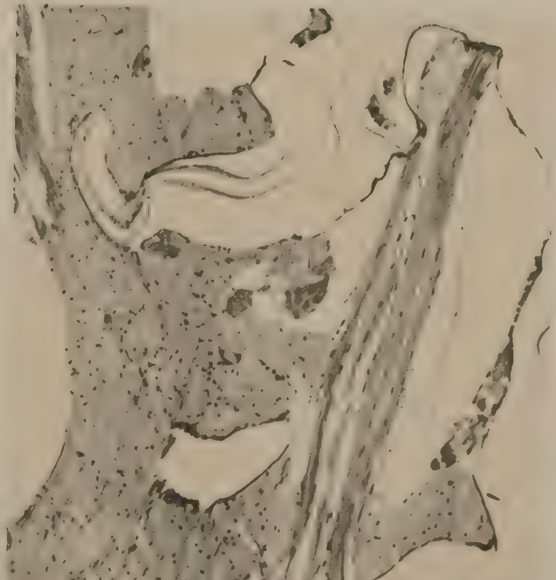








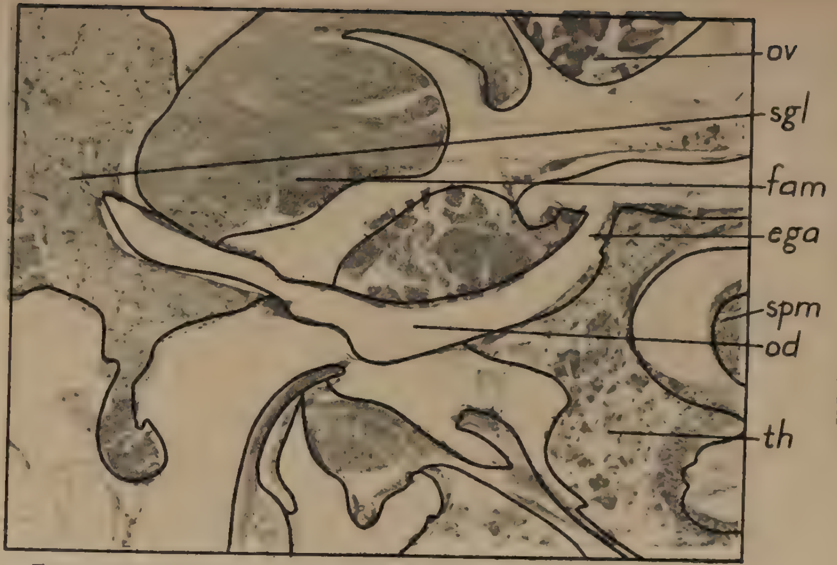


FIG. 1. Transverse section showing external opening of oviduct. *ega*, external genital aperture; *fam*, flexor abdominalis muscle; *od*, oviduct; *ov*, ovary; *sgl*, shell gland; *spm*, sperm mass; *th*, thelycum.

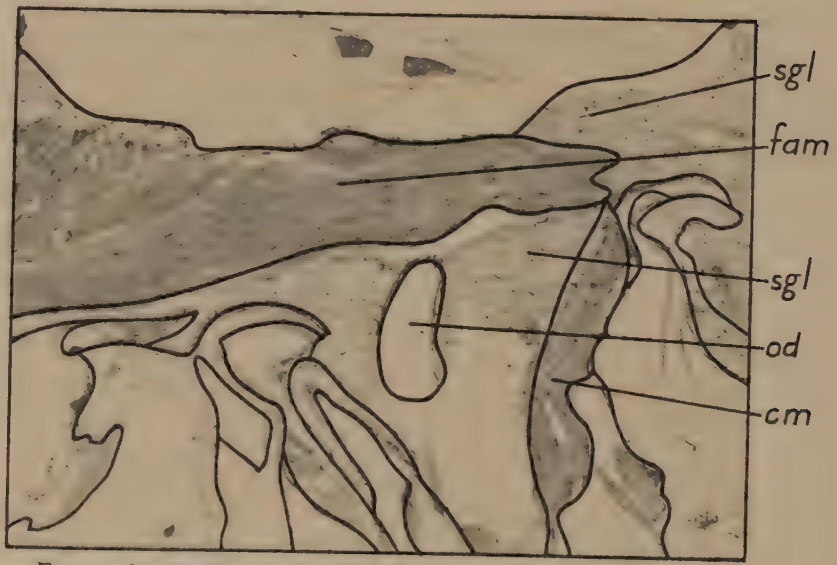


FIG. 2. Longitudinal section showing course of the oviduct in the coxa of the sixth leg. *cm*, coxal muscle.

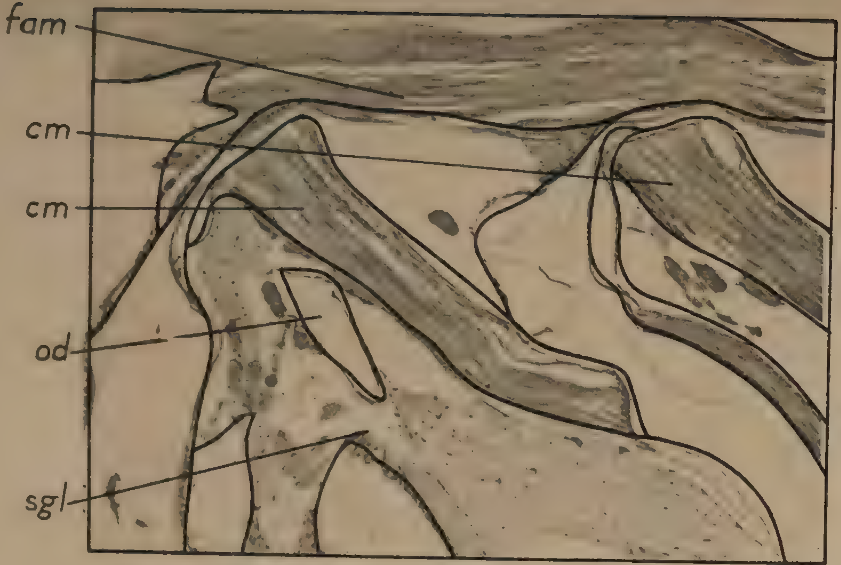


FIG. 3. Longitudinal section showing course of the oviduct in the coxa of the sixth leg. *cm*, coxal muscle.

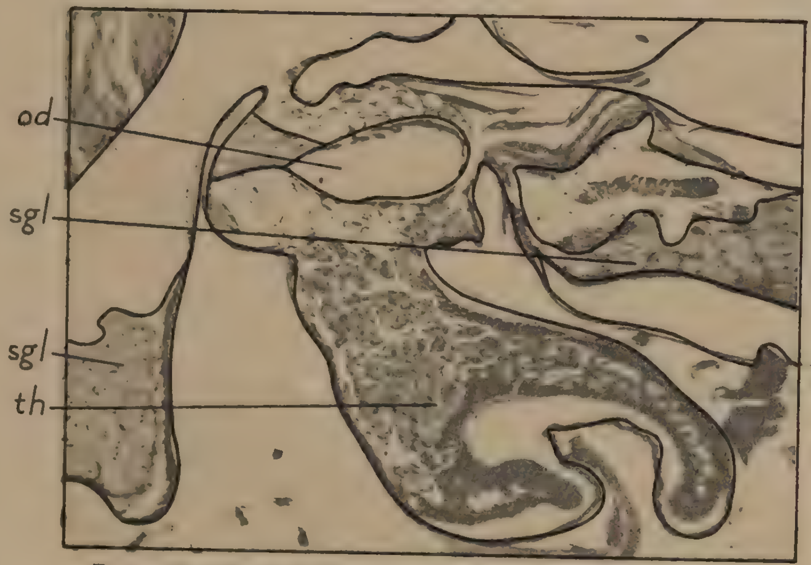
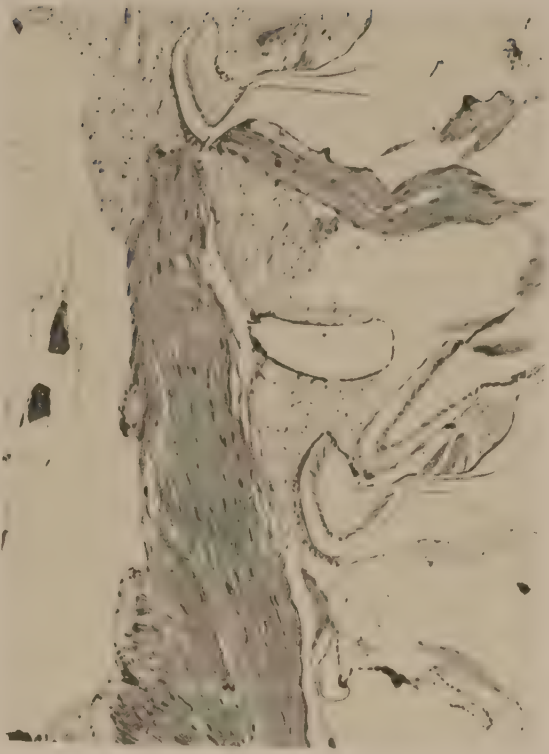


FIG. 4. Longitudinal section showing the oviduct just before it opens to the exterior.

Photomicrographs (× 53) of sections through adult female specimens of EUPHAUSIA SUPERBA.



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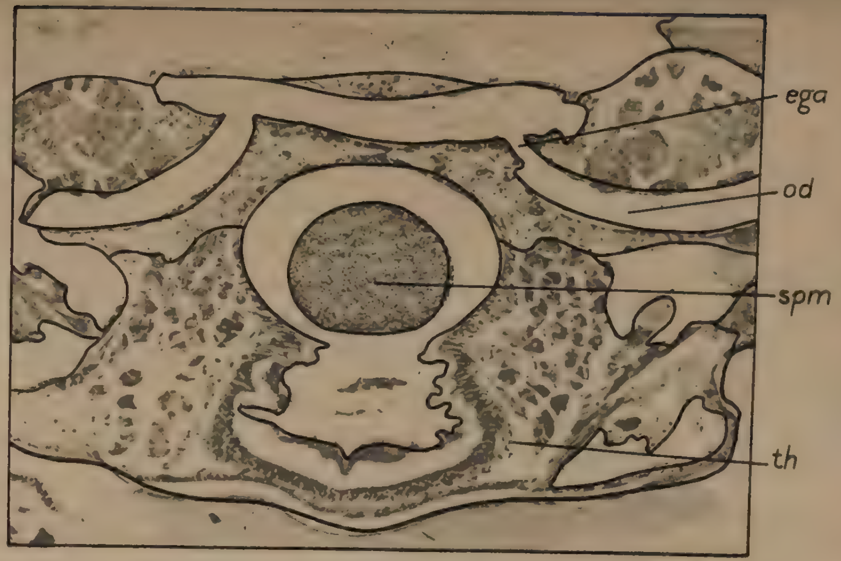


FIG. 1. Transverse section showing external genital apertures, sperm mass and thelycum. *ega*, external genital aperture; *od*, oviduct; *spm*, sperm mass; *th*, thelycum.

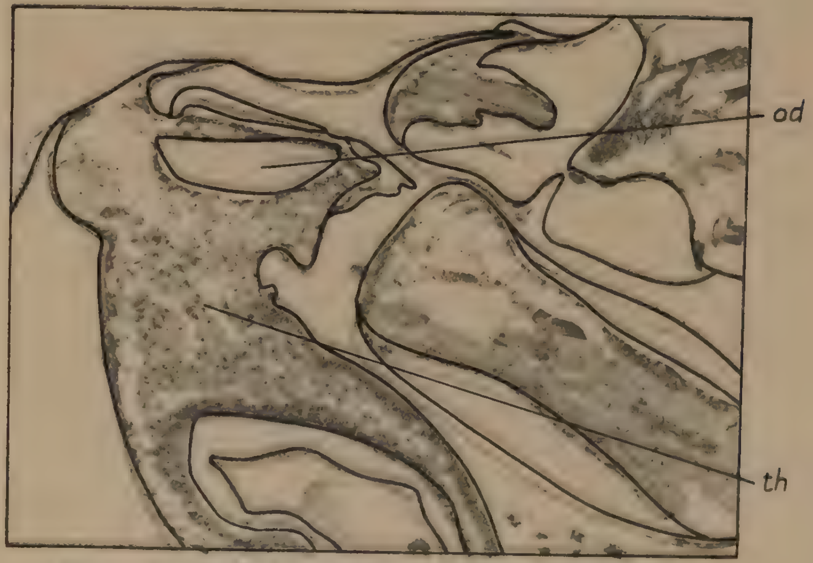


FIG. 2. Longitudinal section through oviduct and thelycum.

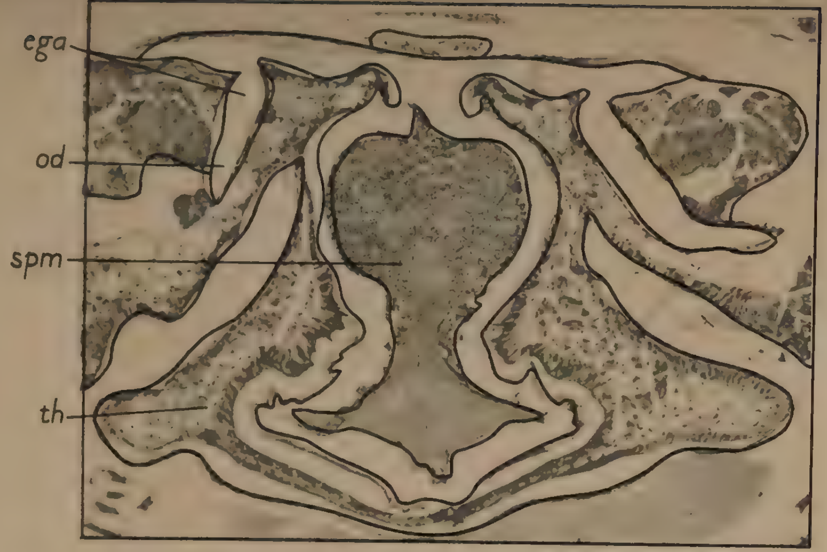


FIG. 3. Transverse section showing relation between the external genital apertures and the opening of the thelycum.

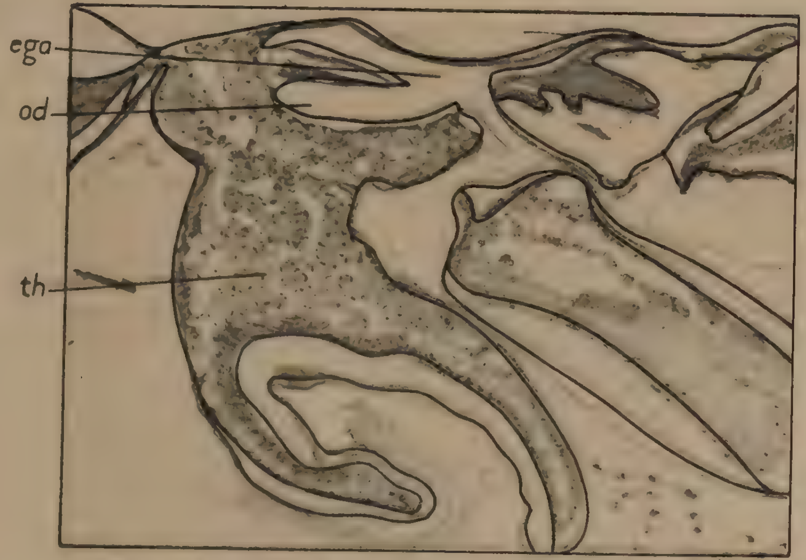
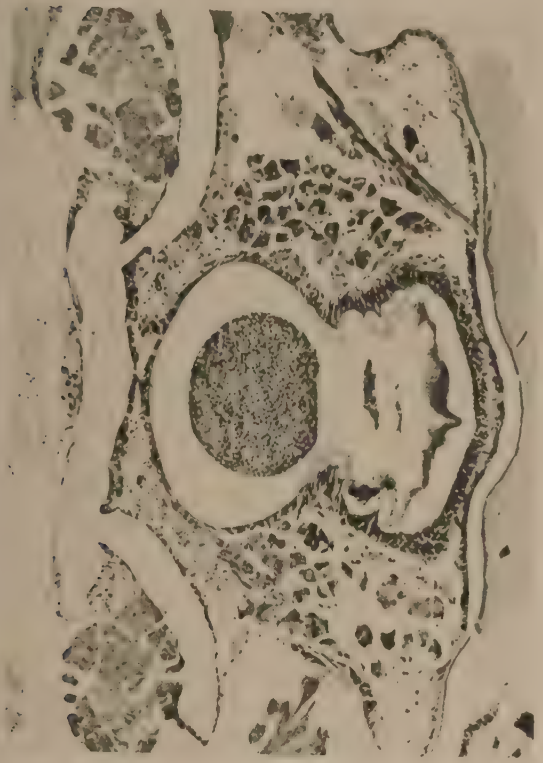
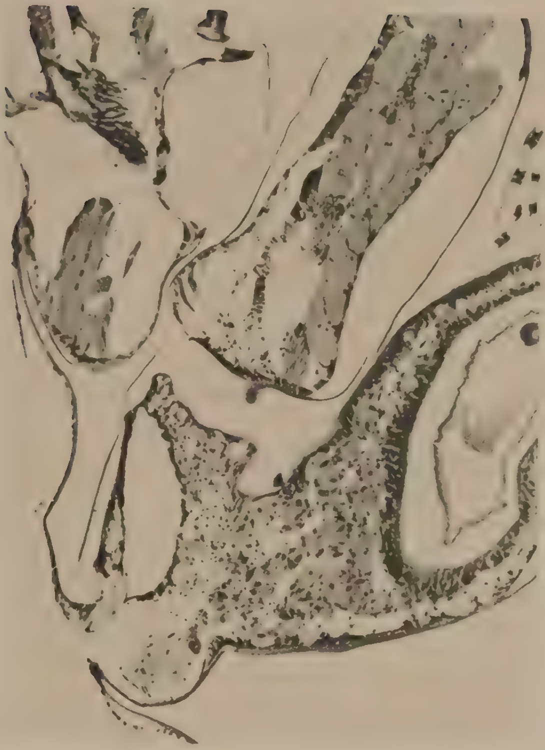


FIG. 4. Longitudinal section showing external genital aperture.

Photomicrographs (× 53) of sections through adult female specimens of EUPHAUSIA SUPERBA.





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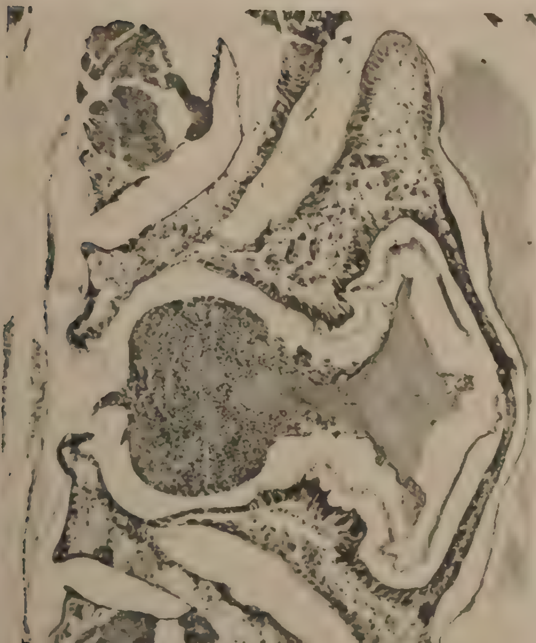

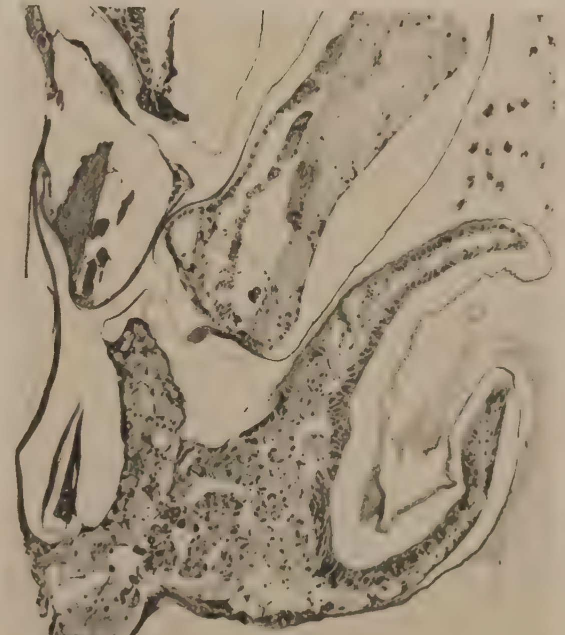

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LARVAE OF DECAPOD CRUSTACEA

PART IV. HIPPOLYTIDAE

By
ROBERT GURNEY, D.Sc.

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LARVAE OF DECAPOD CRUSTACEA

PART IV. HIPPOLYTIDAE

By Robert Gurney, D.Sc.

(Text-figures 1–137)

THE LARVAL GENUS *ERETMOCARIS* BATE

The genus was founded by Bate (1888, p. 895) to include four species of larvae taken in the Pacific near Japan and in the Atlantic near the Cape Verde Islands, all characterized by the great length of the eyestalks. Ortmann (1893, p. 78) described a fifth species, but neither was able to figure the legs, which were all lost. Brooks and Herrick had, however, given excellent figures (1891, pl. ix, x) of a similar larva, probably identical with *Eretmocaris stylorostris* Bate, as the larva of *Stenopus*, and Chun (1888) had described another form under the name of *Miersia clavigera*. Ortmann recognized that both these larvae belonged to Bate's genus. Lo Bianco (1901, p. 439 and 1909, p. 609) reared from *M. clavigera* a post-larval stage which he identified as *Ligur edwardsi*, but Caroli (1918) was able to prove that Chun's larva is actually a stage in the development of *Lysmata seticaudata*.

The larva of *L. seticaudata* is characterized by the great elongation of the eyestalks and the precocious development of leg 5, before the appearance of legs 3 and 4, into an enormously long appendage with a paddle-like enlargement of the propodus. The coxa and basis are correspondingly enlarged, so that even when the rest of the appendage is lost, as it so generally is, it is possible to determine its size in comparison with leg 4. These characters are found in all the four species described by Bate, but *Eretmocaris dolichops* Ortmann, apparently had leg 5 not larger than leg 4, and no doubt does not belong to the same adult genus as typical *Eretmocaris*. Whether Bate's four species can be regarded as all belonging to *Lysmata* is by no means certain, and it is more probable that they represent two or more genera.

I have had the opportunity of examining a large number and variety of these larval forms from the following sources:

(1) At Ghardaqa on the Red Sea I obtained a series of stages including one specimen which moulted to the post-larval stage and permits the identification of the series to which it belonged with *Lysmata*. Although these larvae agree very closely with those of *L. seticaudata* I consider their description of value as tending to establish the characters of the genus and to furnish evidence that *Eretmocaris* is a composite genus.

(2) From the Great Barrier Reef I have a large material for the use of which I am indebted to Mr F. S. Russell. This material enables me to illustrate certain additional specific types which, so far as can be said at present, seem also to fall within the genus *Lysmata*.

(3) Dr Wheeler has been kind enough to give me specimens from Bermuda of two distinct forms, one of which differs strikingly from all the others I have seen in having the propod of leg 4 expanded as well as that of leg 5.

(4) The Discovery material which has been entrusted to me by Dr Kemp contains a few specimens of *Eretmocaris* larvae which are separable into five types, two of which have already been described by Bate.

LARVAE FROM THE RED SEA

Larvae of the *Eretmocaris* type were taken in very small numbers in plankton from the deeper water outside the reef at Ghardaqa, and occasional specimens of stage I appeared at night near the laboratory. Two forms can be distinguished, the most obvious distinguishing character being the presence or absence of dorsal spines on abdominal somite 5; but there can be little doubt that the specimens referred to as "species 2" actually represent two species, since some specimens have supra-orbital spines while others have not. Apart from this difference the larvae, having regard to the scantiness of the material, cannot be separated.

Species **R.S. I, Hippolysmata?**

STAGE I. Length 2·3 mm. (Figs. 1–7).

Rostrum long and slender, reaching end of antennular peduncle. Carapace with anterior and posterior median dorsal tubercles; anterior ventral margin with four teeth. Abdominal somite 5 with a pair of small dorso-lateral teeth. Telson deeply concave behind.

Antennule. Exopod with inner feathered seta and four aesthetes; of these the inner one is short and stout, but bears at its end a spoon-shaped membrane with thickened midrib and distal margin (Fig. 3). It seems to be a general rule in Caridea that there is a feathered seta and four aesthetes, one of which differs from the others in most cases by tapering to a fine point. In *Saron* and a species allied to it I have detected a very delicate membrane on either side of it, but narrower and much more difficult to see than in *Lysmata*.

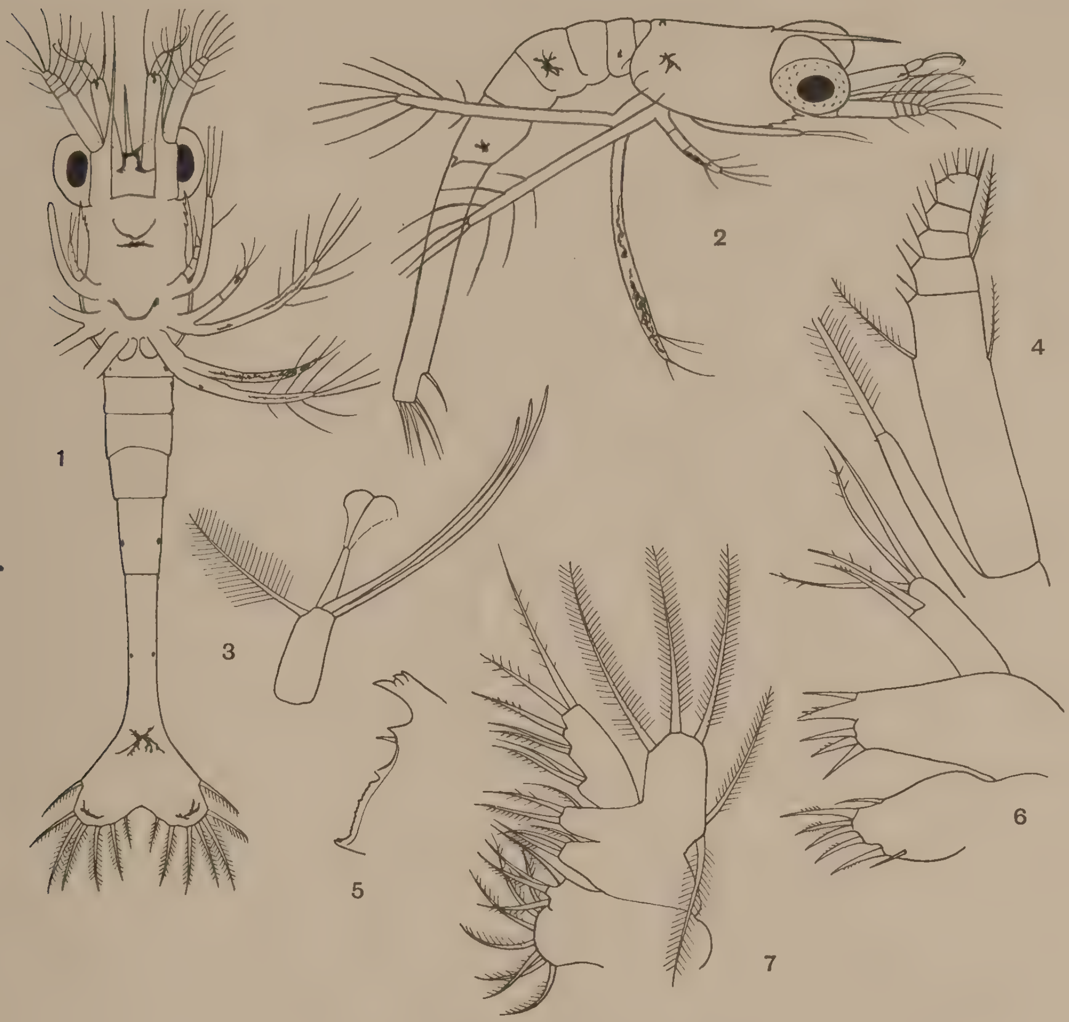
Antennal scale with four distinct segments; two outer setae and eleven inner and terminal; endopod a slender rod bearing a long feathered seta.

Maxillule. Palp unsegmented, with five setae. Maxilla, exopod with five setae; endopod with three small inner lobes bearing setae, unsegmented; four inner laciniae distinct.

Maxillipede 1. Endopod of four segments; exopod with three terminal setae, and one on outer margin; coxa large, with long setae. Maxillipedes 2 and 3 with long exopods bearing three terminal and six lateral setae. One very small leg rudiment.

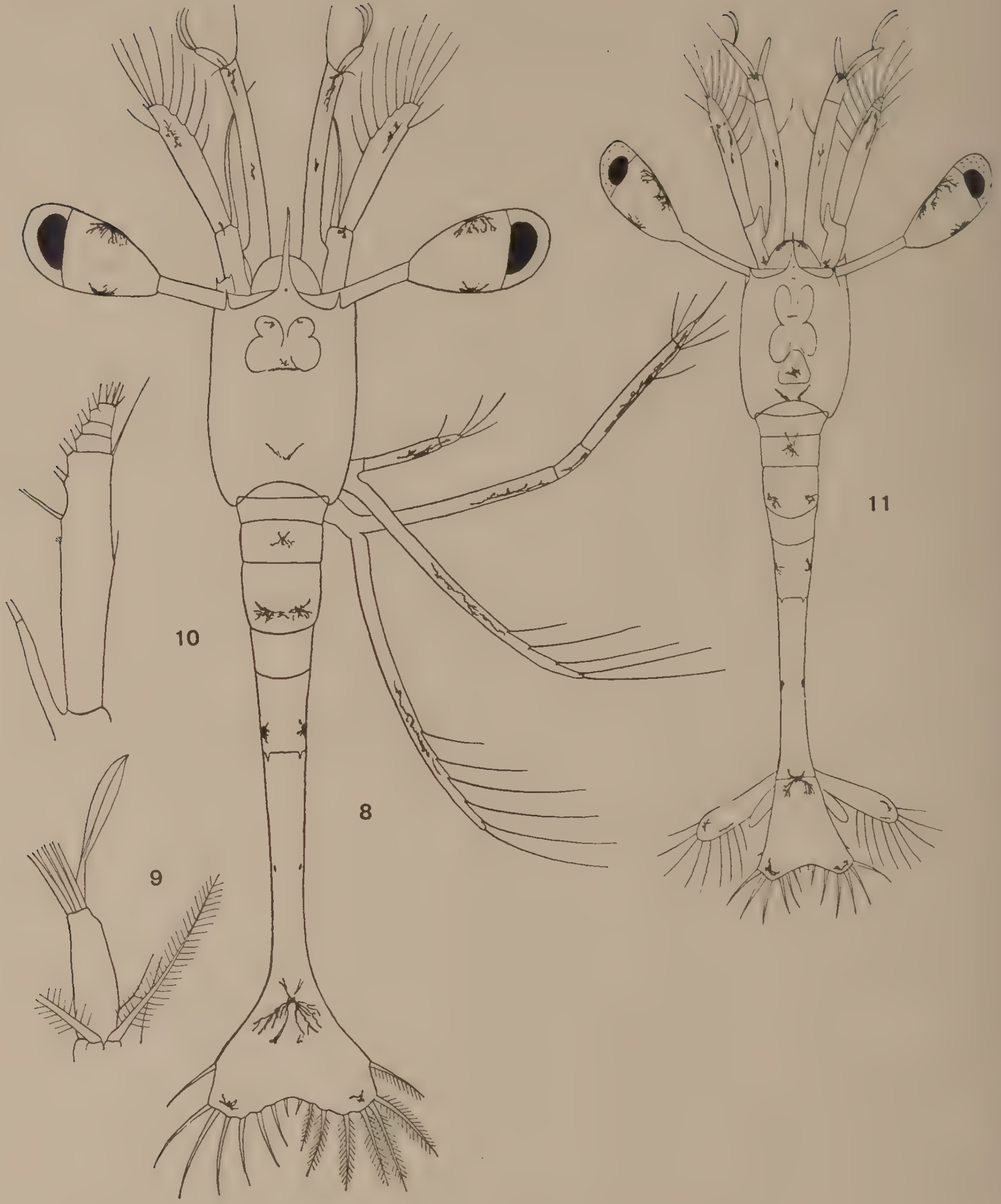
Chromatophores of legs, mouth region and telson dark olive brown; dark red in thorax between maxillipedes, and rosy red in antennules.

The long exopods have a characteristic slow waving motion. There is no definite proof that this larva belongs to the following series, but the general appearance in life and mode of swimming left little doubt in my mind of the relationship. The resemblance to stage I of *Lysmata seticaudata* is very close. It should be noted that the figure of the ventral view does not give a correct idea of the length of the appendages which were seen foreshortened in this position.



Eretmocaris. Species R.S. I, *Hippolysmata*?

Fig. 1. Stage I, ventral. Fig. 2. Stage I, lateral.
Fig. 3. Stage I, end of antennule. Fig. 4. Stage I, antenna.
Fig. 5. Stage I, mandible. Fig. 6. Stage I, maxillule.
Fig. 7. Stage I, maxilla.



Eretmocaris. Species R.S. I, *Hippolysmata*?

Fig. 8. Stage II, dorsal.

Fig. 9. Stage II, end of antennule.

Fig. 10. Stage II, antenna.

Fig. 11. Stage III, dorsal.

Stage II. Length 3 mm. (Figs. 8–10).

Rostrum slender, without dorsal teeth, reaching to base of antennal scale. Carapace with small supra-orbital spines; ventral margin with three teeth. Abdominal somite 5 with a pair of dorsal spines. Telson less deeply concave, with 8 + 8 spines.

Eyes on long stalks about half length of eye; eye with stalk about one-quarter length of body.

Peduncle of antennule one-quarter length of body, unsegmented, with base a little enlarged; exopod apparently lacking the feathered seta, but with five aesthetes of which one, as before, has a membranous border.

Antennal scale with ten inner and terminal setae, but only three distal segments. Outer distal seta much longer than proximal one; endopod shorter and more slender, with seta as before. Exopods of maxillipedes 1–3 with four terminal setae; maxillipede 2 with six and maxillipede 3 with eight lateral setae. Leg 1 a large biramous rudiment.

Stage III. Length 3·5 mm. (Fig. 11).

Rostrum short, not reaching base of antennal scale. Telson separated from somite 6, slightly broader than long, with 8 + 8 spines, of which one is lateral.

Eyestalk longer and more slender than in stage II; eye with stalk to body as 1 : 3·5. Peduncle of antennule as long as eye, of two segments, and with small endopod. Antennal scale unchanged; flagellum reduced to a very small knob without a seta.

Leg 1 developed, with exopod.

Pleopods absent. Uropods developed, the endopod small, without setae.

Of this form I have no older stages.

Species R.S. II, **Lysmata** sp.

Stage II. Length 2·5–2·7 mm. (Fig. 12).

Rostrum very small, not extending beyond frontal lobe. Carapace with anterior and posterior papillae, but no median spine; supra-orbital and antennal spines absent; pterygostomial spine present, and two small marginal teeth. Abdominal somite 5 without dorsal spines. Telson not deeply concave, with 8 + 8 spines (in one specimen 7 + 7 only).

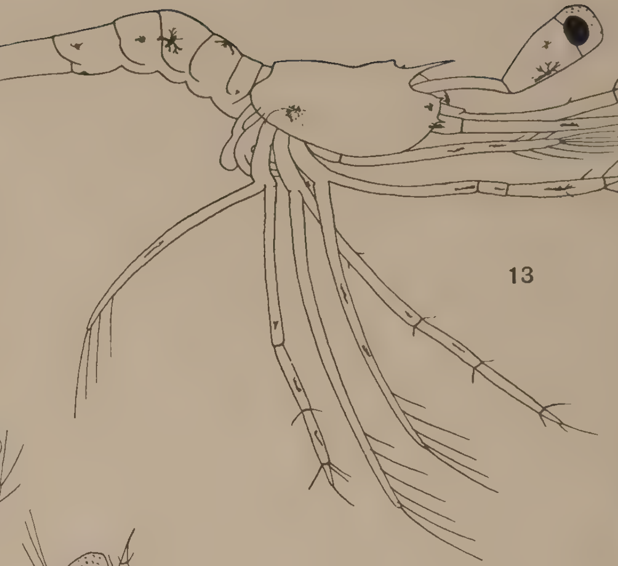
Eye with stalk about one-third length of body. Peduncle of antennule nearly one-third of body length. Antennal scale very long and slender, with eleven inner and terminal setae; two distal segments distinct; one outer seta near end; endopod a very small process one-tenth length of scale.

Leg 1 fully developed, endopod very long and slender. Leg 5 fully developed, the propod very long and slightly expanded; lengths of segments (in mm.):

Ischio-merus	Carpus	Propodus	Dactylus
1·48	1·14	1·3	·06

Between legs 1 and 5 is a single large biramous rudiment. Exopods of maxillipedes and leg 1 with four terminal setae; total setae 5, 10, 12, 10. Pleopods absent.

General colour red.



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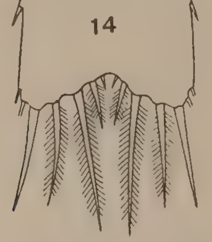

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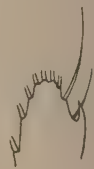

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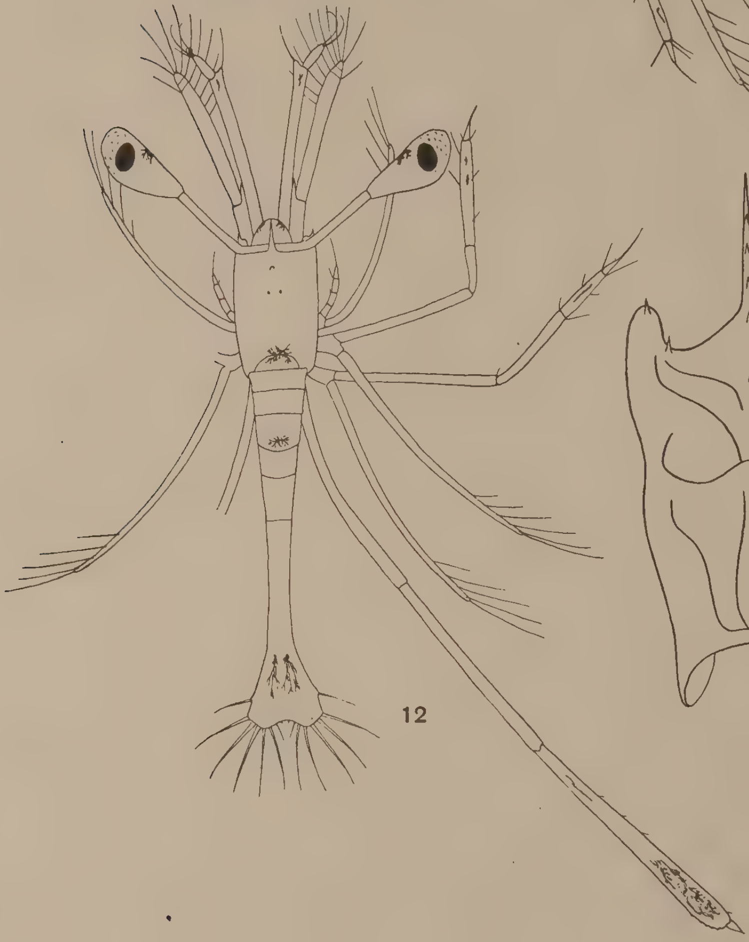

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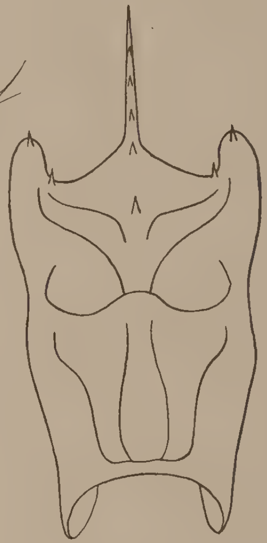

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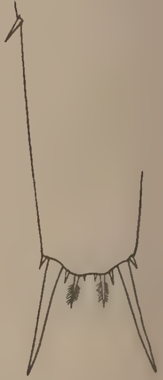

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Eretmocaris. Species R.S. II, *Lysmata* sp.

Fig. 12. Stage II, dorsal.
Fig. 13. Stage IV, lateral.
Fig. 14. Stage IV, part of telson.
Fig. 15. Stage IV, part of antennal scale.
Fig. 16. Stage IX, carapace, dorsal.
Fig. 17. Stage IX, part of telson.

It will be seen that this stage differs very much from the corresponding stage in species I in having legs 1 and 5 fully developed. In this respect it agrees with *L. seticaudata* as described by Caroli. It is very doubtful if species I really belongs to this genus.

I have seen no specimens of stage III.

STAGE IV? Length 4·3 mm. (Figs. 13–15).

Rostrum very small. Carapace with minute tooth in front of anterior tubercle; supra-orbital spine absent, but antennal and pterygostomial spines present.

Telson widest at end; greatest width equal to half length; one pair of lateral spines and two small spines at each angle, 8 + 8 in all. Anal spine absent.

Eye with stalk to body as 1 : 3·5. Antennular peduncle as long as eye. Antennal scale slender, with outer distal spine and no segmentation; flagellum very small.

Legs 1, 2 and 5 fully developed, but leg 5 lost. Legs 3 and 4 rudimentary. Pleopods absent. Endopod of uropod with setae.

STAGE V? Length 5·45 mm.

Rostrum small, without teeth. Carapace with median dorsal tooth. There is a well-marked groove in the gastric region from which lines can be faintly traced forwards and downwards. These lines seem to be characteristic of this type of larva and will be shown in figures of other forms in which they are clearer.

Telson nearly three times as long as wide, with 6 + 6 spines, of which one pair is lateral and one at the angle; apparently one of the small spines at the angle and the innermost spine are lost at this stage.

Peduncle of antennule 1·4 mm., with rudiment of stylocerite; flagella about two-thirds length of peduncle. Antennal scale nine times as long as wide; flagellum one-sixth of its length. Mouth-parts differing little from stage I. Exopod of maxilla with fifteen setae, broad in front.

Maxillipede 1 with endopod of four segments; coxa well developed with long setae; exopod with five setae. All legs fully developed, but leg 5 lost. Pleopods absent.

Between stage V and the last stage I have only a single specimen. Judging by the increase in length of the carapace, it seems there must be three, or perhaps four, intermediate stages, making eight or nine in all. Caroli describes eight stages in *L. seticaudata*, but admits that there may be a stage intermediate between his sixth and "penultimate", making a total of nine.

STAGE VIII? Length 7 mm.

Rostrum with one large dorsal spine. Carapace with supra-orbital, antennal and pterygostomial spines, and with large median dorsal spine; surface with lines well marked.

Telson nearly three times as long as wide, with two pairs of small lateral spines and 5 + 5 distal spines.

Eye with stalk about one-third length of body. Peduncle of antennule 1·9 mm.;

endopod 2·55 mm.; exopod faintly segmented, with three groups of aesthetes; stylocerite large.

Flagellum of antenna as long as scale.

Legs 1 and 2 not chelate. Pleopods large.

This specimen is included in this series, although the presence of a supra-orbital spine shows that it must belong to a distinct species.

Stage IX? (Figs. 16–19).

One specimen in the last stage was taken in plankton and moulted the same night to the post-larval stage. As the animal was not examined alive I have only the moulted skin for description.

Rostrum 1 mm. long, with four dorsal teeth. Carapace 1·9 mm. long, without supra-orbital spines, but with dorsal, antennal and pterygostomial spines. A series of lines are clearly marked (Fig. 16). These lines, which do not seem to bear any relation to the carapace lines described by Boas and others, are repeated in almost exactly the same arrangement in specimens from the Barrier Reef and Bermuda. In a specimen from Bermuda, which was examined very soon after preservation, they were very clearly picked out in red. In *Caridion gordoni* there are two transverse red lines, the one immediately in front of the anterior tubercle, and the other running across from the gastric groove. They correspond to the two transverse lines in *Lysmata*, but the posterior longitudinal lines cannot be traced. It is possible that they may none the less exist and be visible in the moulted skin.

Abdominal somite 5 without dorsal spines; somite 6 3·6 times as long as deep. Telson 1·3 × 0·45 mm. with one pair of lateral spines and 5 + 5 terminal spines, of which the second is very large. Anal spine absent.

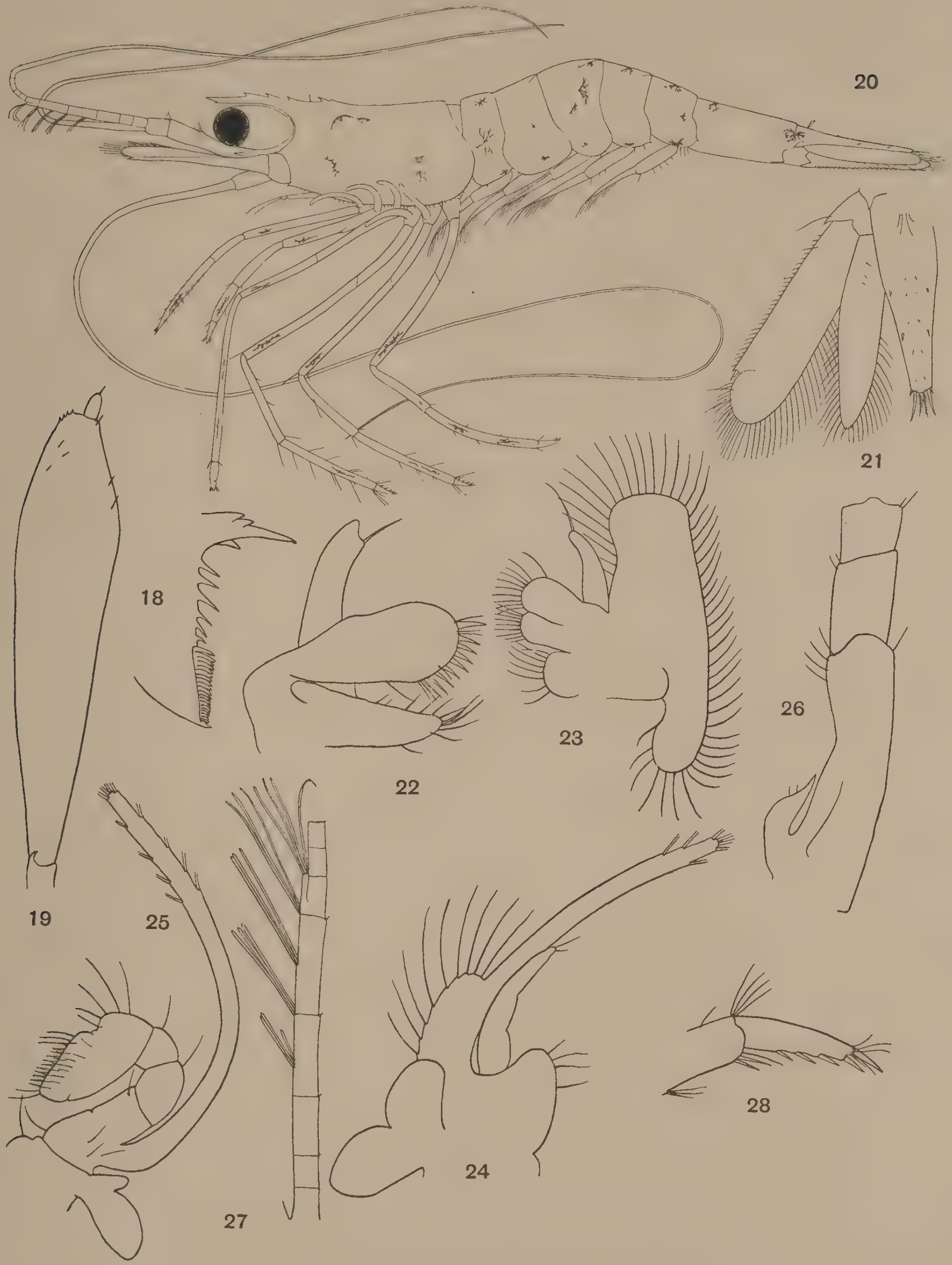
Peduncle of antennule 1·95 mm., with small stylocerite; outer flagellum 4·9 mm. long, segmented, with aesthetes on segments 2, 3, 4. Antennal scale 1·85 × 0·35 mm., flagellum very long.

Mouth-parts of the same form as in earlier stages. Exopod of maxilla very large, somewhat truncated in front.

Maxillipede 1 with exopod expanded at base and bearing here ten setae; distal part with six setae. Legs 1 and 2 subchelate. The following table gives measurements (in mm.) of the legs. Leg 4 is lost. Propod of leg 5 expanded, the length about 4½ times the width.

Pleopods large, with rudimentary setae.

	Dactylus	Propodus	Carpus	Ischio-merus	Total
1	0·17	0·56	0·73	1·3	2·76
2	0·14	0·25	1·67	2·0	4·06
3	0·25	1·55	1·1	2·75	5·65
5	0·2	3·0	1·85	3·72	8·77



Eretmocaris. Species R.S. II, *Lysmata.*

Fig. 18. Stage IX, mandible.
Fig. 19. Stage IX, end of leg 5.
Fig. 20. Post-larval stage I, lateral.
Fig. 21. Post-larval stage I, telson and uropods.
Fig. 22. Post-larval stage I, maxillule.
Fig. 23. Post-larval stage I, maxilla.
Fig. 24. Post-larval stage I, maxillipede 1.
Fig. 25. Post-larval stage I, maxillipede 2.
Fig. 26. Post-larval stage I, peduncle of antennule.
Fig. 27. Post-larval stage I, part of outer flagellum.
Fig. 28. Post-larval stage I, dactyl of leg 4.

Post-larval Stage I (Figs. 20–28).

Length 9·8 mm. Moulted from last larval stage.

Rostrum as long as eyes, with three dorsal and one ventral tooth. Carapace with median dorsal tooth and small antennal and pterygostomial spines, but no supra-orbital. Pleura of abdominal somites 4 and 5 with small spine; somite 6 twice as long as deep.

Telson shorter than uropods, nearly 3½ times as long as wide, with two pairs of dorsal spines; sides fringed with setae; posterior margin with small spine at angle and a pair of long spines, between which is a pair of feathered setae. No anal spine.

Basal segment of antennule with pointed stylocerite; outer flagellum with five groups of aesthetes on segments 4–6; sixth segment divided, with rudimentary accessory branch.

Mandible without palp or incisor process. Maxillule with proximal lacinia pointed; palp small, with one apical seta. Maxilla with three inner laciniae, the proximal one reduced; palp small, with one seta.

Maxillipede 1 with large bilobed epipod; exopod expanded at base and with eight terminal setae; endopod unsegmented with two small apical setae. Maxillipede 2, epipod with small lobe representing rudiment of podobranch; exopod with twelve setae; endopod bent downwards at carpus, dactylus fused with propod. Maxillipede 3 with rudimentary epipod; exopod reduced and without setae; dactyl and propod fused, this segment more than twice length of carpus, and a little shorter than ischio-merus.

Leg 1 with small chela, propod shorter than carpus. Leg 2 carpus very long, faintly divided into twenty-eight segments. Legs 3–5 about equally long, dactylus of 3 and 4 with four inner spines. Legs 1–4 with large vestigial exopods. Epipods absent.

Pleopod 1 endopod less than half as long as exopod, without appendix interna. Pleopod 2 endopod shorter than exopod, without appendix masculina. Exopod of uropods with outer spine near end, and partial joint at this point.

There can be no doubt that this specimen belongs to the genus *Lysmata*, though the mouth-parts are far from having reached the form characteristic of the adult, and the epipods have not yet appeared. At the same time the general form of these appendages fully agree with those of *Lysmata*, the outer flagellum of the antennule shows a distinct rudiment of the accessory flagellum, and the carpus of leg 2 is divided into many segments. In addition the absence of a supra-orbital spine is regarded as a feature of the genus.

The identification of the species at this early stage is out of the question, though the only species recorded from this region is *L. trisetacea* Heller.

It is of interest to note the reduction of the exopod of maxillipede 3. Reduction at this transitional stage seems to be the rule in Caridea, and its significance is unknown.

LARVAE FROM THE GREAT BARRIER REEF

The Barrier Reef material examined includes 157 specimens of *Eretmocaris*, which appears to be very common in these waters. No stages earlier than stages 4 or 5 have been seen, although I have searched a number of the plankton samples for younger specimens. The material is, on the whole, very well preserved, but leg 5 is generally lost, only eighteen specimens having retained one or both of these legs.

Three distinct species can be separated by easily observed characters, and the following numbers show the relative frequency:

Species 1	Species 2	Species 3
132	15	10

It may well be that two species are included in "species 1", separable by small details in rostrum, length of eyes and antennule; but I have not attempted a revision of the material to determine this point. As none of the species can be named it seems sufficient to establish the more marked types which can be easily recognized. All seem to belong to one genus, and that probably is *Lysmata*.

Two species, *Eretmocaris remipes* Bate and *E. longicaulis* Bate have been described from the neighbourhood of Japan, but neither of these can be identified with any of the Barrier Reef species.

I give below short descriptions of the oldest specimens of each form.

Species **B.R. I** (Figs. 29, 30)

Length less than 8 mm.

Rostrum very short, with one dorsal spine.

Carapace with median dorsal spine, and antennal and pterygostomial spines; supra-orbital spines small or absent. There is a deep transverse groove in the gastric region and lines as described above.

Eye about as long as stalk, together less than one-third length of body.

Telson about three times as long as wide, with two pairs of lateral spines and 5 + 5 terminal spines of which the second is the longest. No anal spine.

Peduncle of antennule nearly one-third length of body.

Leg 5 ischium and merus when distinguishable about equal, together twice length of carpus; propod about $1\frac{1}{2}$ times length of carpus and $5\frac{1}{2}$ times longer than wide.

Species **B.R. II** (Figs. 31–35)

Length up to 7 mm.

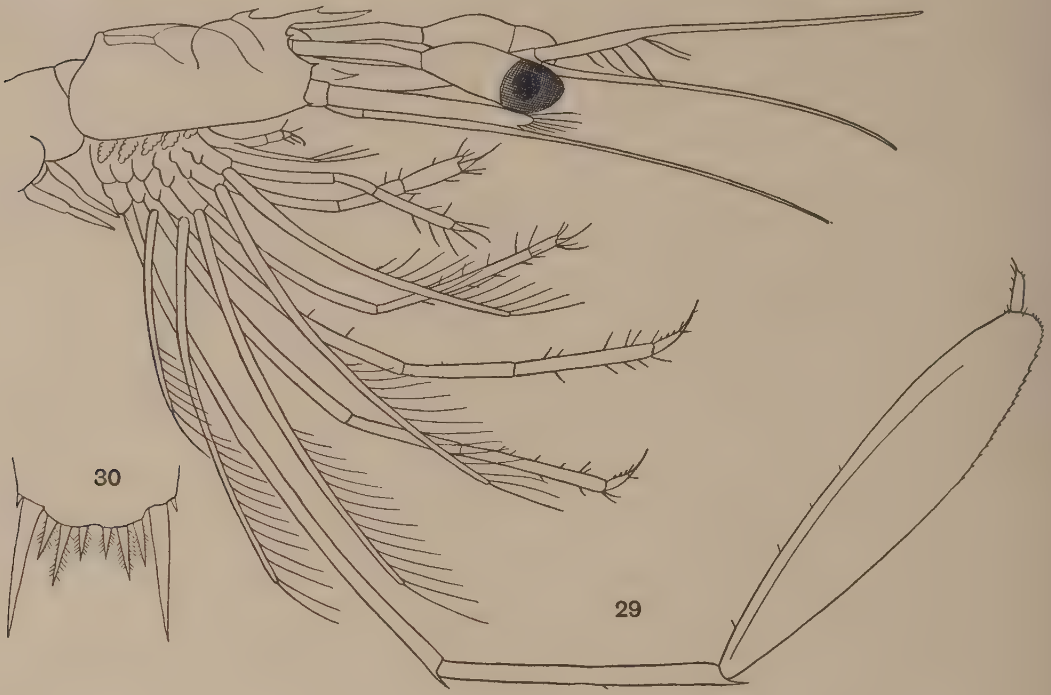
Rostrum long and slender, with three dorsal spines.

Carapace with median dorsal spine large and forming a procurved hook; antennal and pterygostomial spines present, but no supra-orbital. Carapace not deeply grooved, and lines not traceable. Telson a little more than three times as long as wide, without lateral spines and with 5 + 5 terminal spines of which 2 and 4 are the longest.

Eyestalk much shorter than eye, together less than one-third length of body. Peduncle of antennule one-quarter length of body.

Maxilla, exopod broad and truncated in front: endopod with three distinct seta-bearing lobes. Maxillipede 1, endopod of four segments: exopod expanded at base and bearing here ten setae: coxa large, with long setae: epipod large, bilobed. Maxillipede 2 with epipod.

Leg 5 ischio-merus a little more than twice length of carpus; propod less than 1½ times length of carpus, its width a little more than one-third of the length.



Eretmocaris. Species B.R. I.

Fig. 29. Species B.R. I. Fig. 30. Species B.R. I, part of telson.

Species **B.R. III**

Length up to 4·6 mm.

Rostrum very small, without dorsal spine.

Carapace with dorsal and pterygostomial spines, but without supra-orbital and antennal spines; lines not clearly traceable.

Telson three times as long as wide, with two pairs of lateral spines and 5 + 5 terminal, of which the second is very long, and the fourth about half its length.

Eyestalk more than twice as long as eye, together more than half length of body (body : eye as 1·22–1·5 : 1).

Antennular peduncle nearly half length of body, with rudiment of stylocerite.

Mouth-parts as in species B.R. I. Maxilla with exopod broad and truncate in front. Leg 5 absent in all specimens.

In all three species the youngest specimens have leg 5 fully developed while leg 4 or legs 3 and 4 are rudimentary.

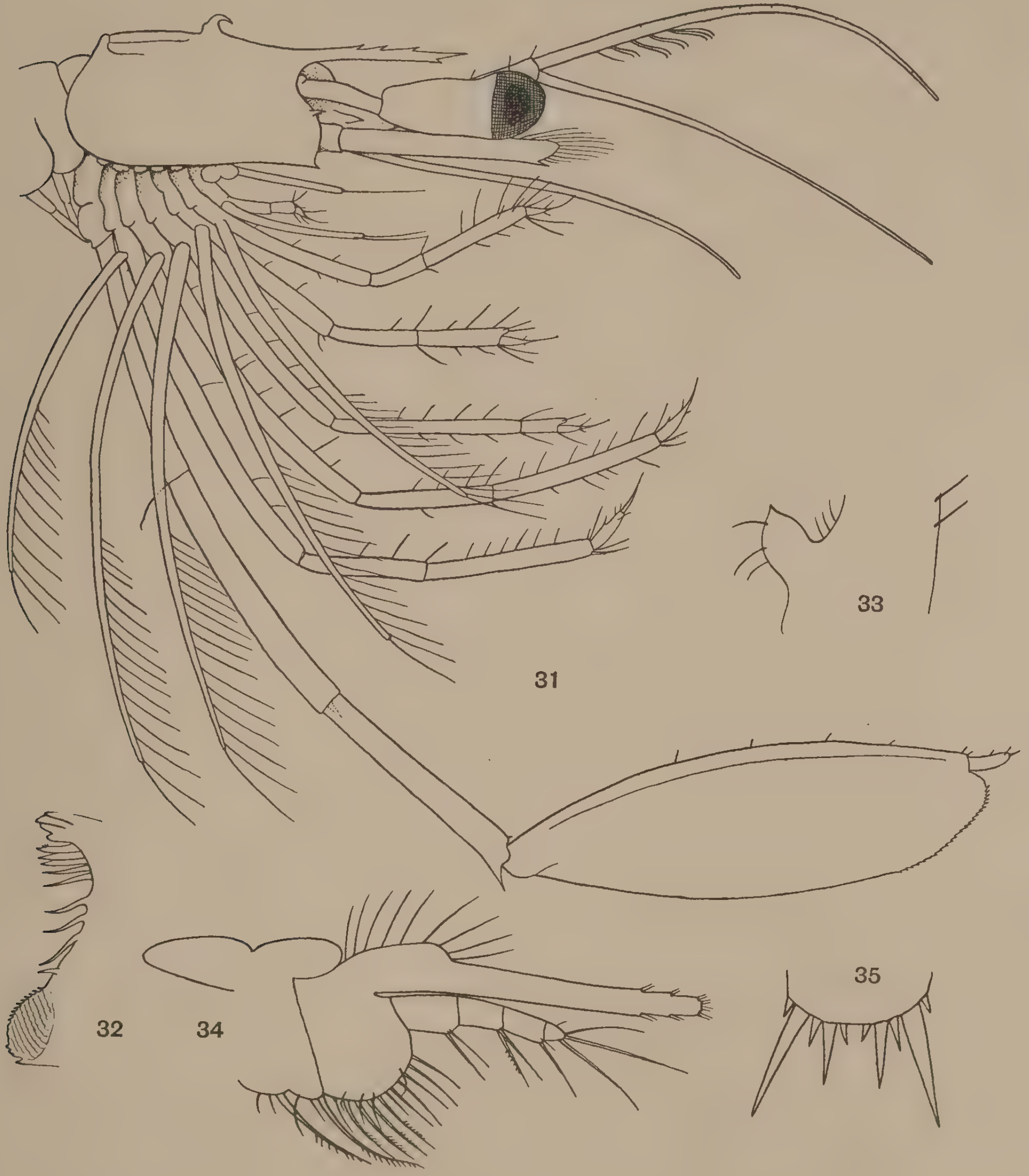
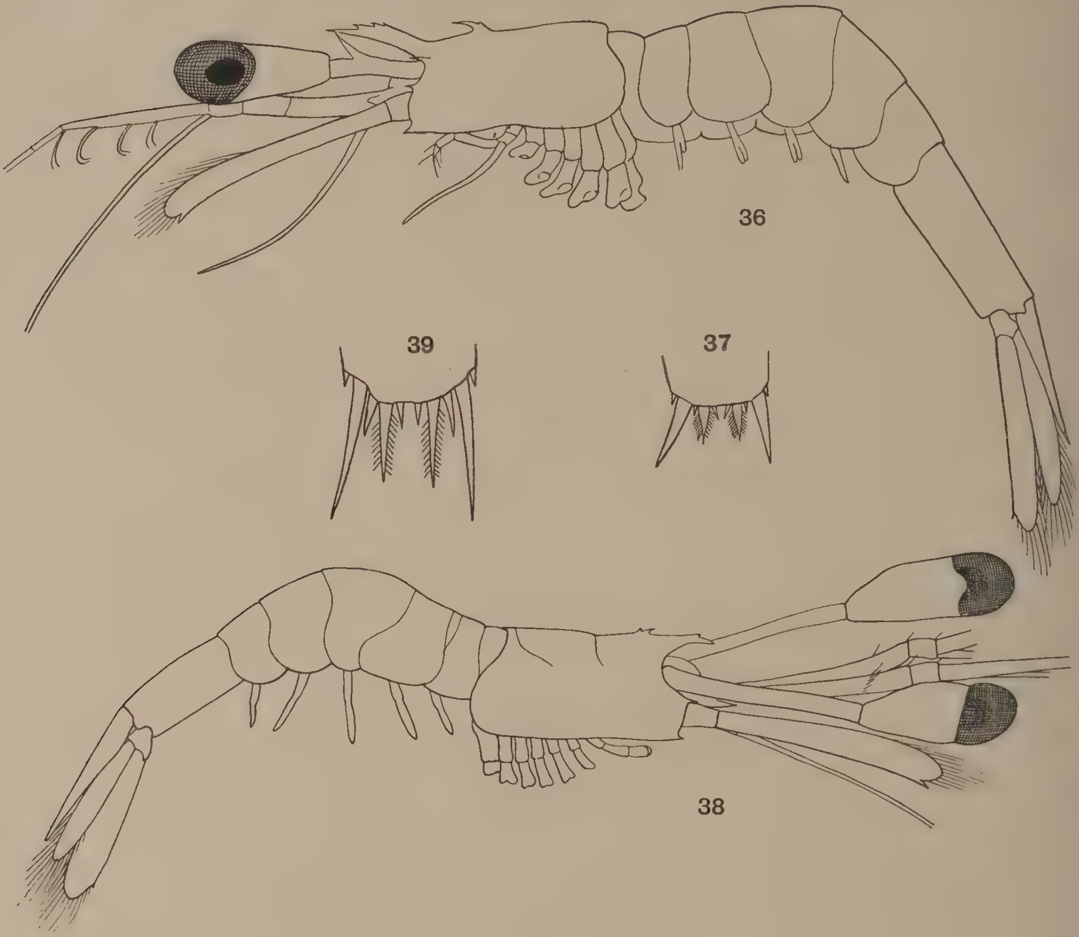


Fig. 31. *Eretmocaris*. Species B.R. II.
Fig. 33. Species B.R. II, base of antennule.
Fig. 35. Species B.R. II, part of telson.
Fig. 32. Species B.R. II, mandible.
Fig. 34. Species B.R. II, maxillipede 1.

LARVAE FROM THE ATLANTIC

The Discovery material includes a small number of larvae which, by reason of their long-stalked eyes, may be assigned to the genus *Eretmocaris*. Two of them can be certainly identified with *E. corniger* Bate and *E. dolichops* Ortmann, while a third almost certainly belongs to *Lysmata seticaudata*.[1] Of the other two, one is characterized by the possession of a spine on the eyestalk, and in this respect resembles a larva described by Kemp (1916) as probably belonging to *Hippolysmata ensirostris*. The other two represent types not previously described.



Eretmocaris. Species A. I, A. II.

Fig. 36. Species A I.
Fig. 38. Species A II.
Fig. 37. Species A I, part of telson.
Fig. 39. Species A II, part of telson.

In addition to these Atlantic forms from the 'Discovery' I have a few specimens from Bermuda for which I am indebted to Dr Wheeler. Neither of these seem to be represented in the Discovery collection. There are, therefore, apart from *Lysmata seticaudata*, at least seven distinct types of *Eretmocaris* larvae from the Atlantic. One of the Bermuda forms is perhaps the same as that described by Brooks and Herrick, and may be identical with *E. stylorostris* Bate.

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[1] From Station 708, 10° 20′ S, 34° 54′ W.

Species **A. I** (Figs. 36, 37)

See Kemp, 1916, *Rec. Ind. Mus.* XII, p. 403, fig. 5. *Hippolysmata ensirostris.*
St. 701. 14° 39′ N, 25° 51′ W. Two specimens.
St. 709. 14° 01′ S, 36° 30′ W. One specimen.

Length 6·14 mm.

Rostrum reaching end of eyestalk, with three dorsal teeth near end. Carapace with large dorsal tooth and supra-orbital, antennal and pterygostomial spines. Abdominal somites without spines, pleura rounded; somite 6 nearly three times as long as deep. Telson shorter than uropods, without lateral spines and with 5 + 5 terminal spines, of which spine 2 is the longest.

Eyestalk shorter than eye, with large dorsal spine; eye and stalk to length of body as 1 : 3·7.

Peduncle of antennule reaching nearly to end of eye; rami long, but broken. Flagellum of antenna about as long as scale. Legs all lost, the stumps increasing in size backwards and arranged in a semicircle, leg 1 widely separated, leg 5 closely apposed. Leg 4 with exopod. Pleopods present, small.

These three larvae represent a younger stage than that figured by Kemp, which is no doubt the last stage and has the rostrum very much longer and with numerous dorsal teeth.

Specimens of precisely the same form were taken by the 'Discovery' at six stations off the east coast of Africa.

Species **A. II** (Figs. 38, 39)

Eretmocaris stylorostris Bate, 1888, pl. xcv, fig. 3?.
Stenopus hispidus Brooks and Herrick, 1892, pls. ix, x?.
St. 709. 14° 01′ S, 36° 30′ W. One specimen.

Length 6·1 mm.

Rostrum small, with one dorsal tooth. Carapace with small dorsal tooth and antennal and pterygostomial spines; supra-orbital spine absent. Abdominal somites without spines, pleura rounded; somite 6 not much more than twice as long as deep.

Telson three times as long as wide, without lateral spines: terminal spines 5 + 5, of which 2 and 4 are longest.

Eyestalk longer than eye, together nearly half length of body.

Peduncle of antennule shorter than eye, about one-third length of body. Legs all broken off, but stump of leg 5 larger than that of leg 4, which has an exopod. Pleopods large.

Bate's *Eretmocaris stylorostris* may be an earlier stage of this species. The species figured by Brooks and Herrick differs in having the eyes considerably shorter, but may well be the same species.

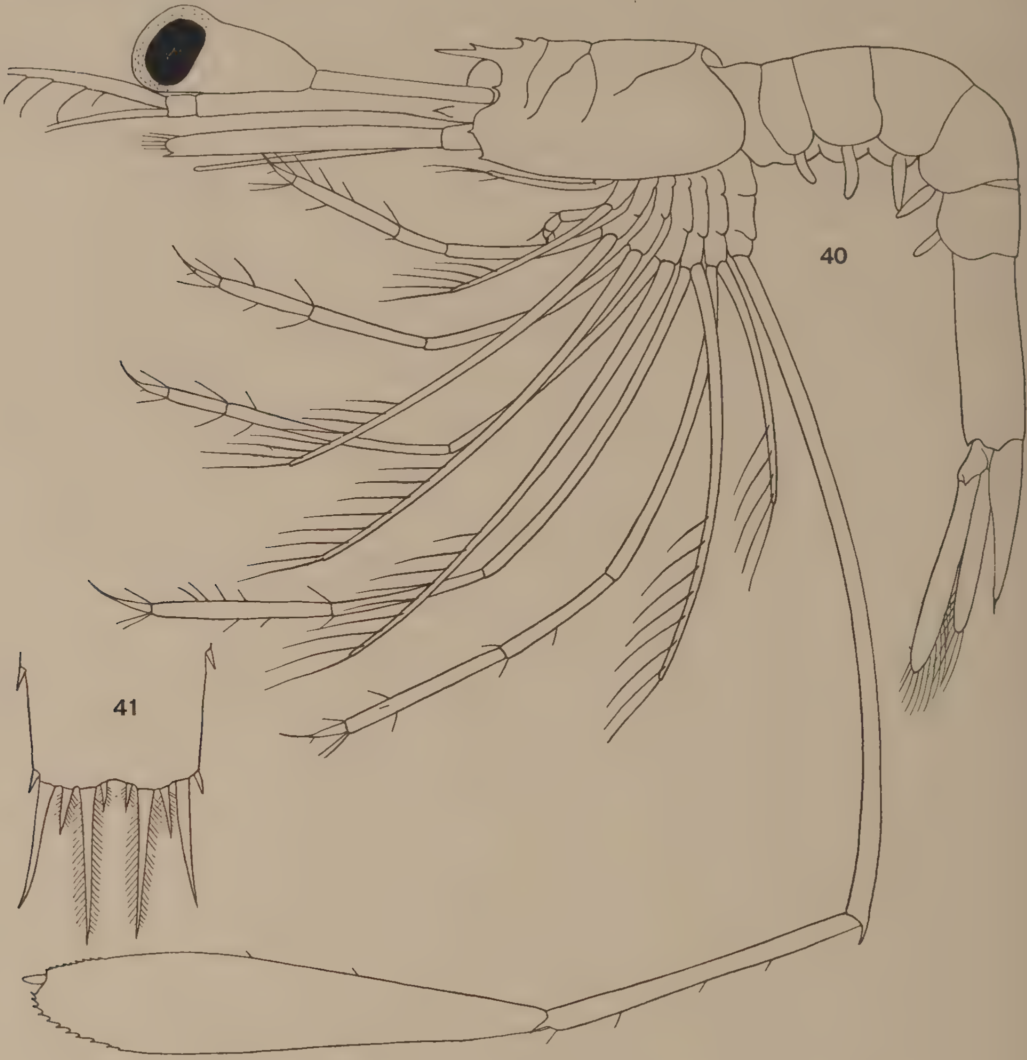


Fig. 40. *Eretmocaris*. Species A. III. Fig. 41. Species A. III, part of telson.

Species **A. III** (Figs. 40, 41)

Bermuda. 28. v. 35. Several specimens of same stage.

Length 6·08 mm.

Rostrum short and straight, with one dorsal tooth. Carapace with small dorsal tooth and supra-orbital, antennal and pterygostomial spines. Lines on carapace well marked. Abdominal somite 6 three times as long as deep.

Telson shorter than uropods, with two pairs of very small lateral spines and 5 + 5 terminal spines, of which the second and fourth are much the longest.

Eye and stalk about equal, together about one-third length of body. Peduncle of antennule a little shorter than eye.

Legs 1 and 2 not chelate, but leg 2 with very long carpus and very short propod. Leg 2 longer than leg 1 and leg 3 than leg 2; leg 4 shorter than leg 3, slender, with exopod. Leg 5 enormously developed; ischium and merus not distinct; merus and carpus each with terminal spine; propod flattened and expanded, the distal margin on both sides serrated; length five times the greatest width. Pleopods small.

An older specimen differs little from description given, but legs 1 and 2 have rudimentary chelae, and the telson has lost the lateral spines, while spine 4 is very much smaller than spine 2.

Species **A. IV** (Figs. 42–49)

Bermuda. Jan. 1935.

Length 9·05 mm.

Rostrum nearly as long as segment 1 of antennule, with one dorsal tooth. Carapace with dorsal tooth, and supra-orbital, antennal and pterygostomial spines, the two latter very small. In this specimen, which was examined soon after preservation, the lines shown on the carapace were distinctly marked in red.

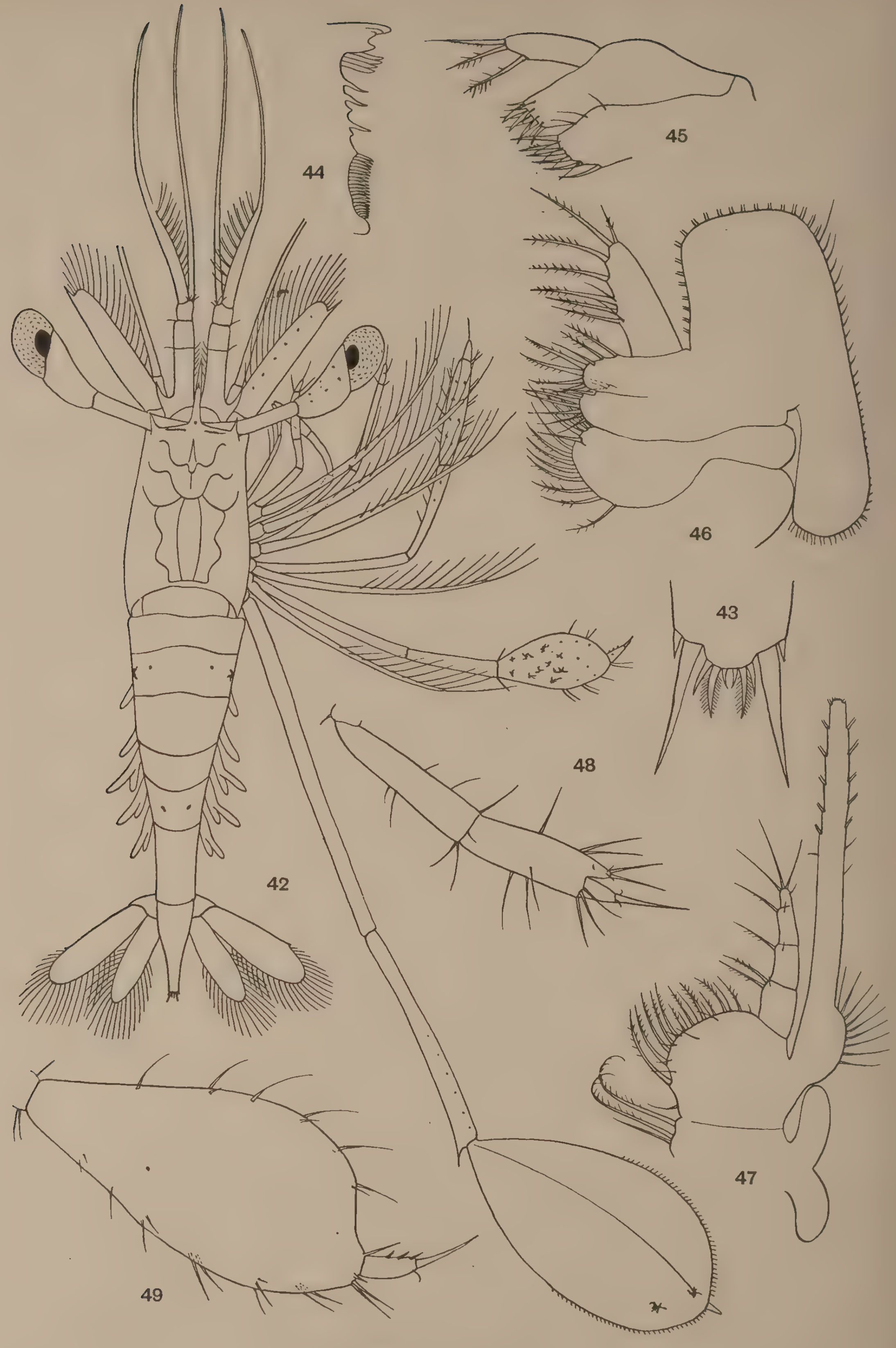
Telson $3\frac{1}{2}$ times as long as wide, without lateral spines; apex with $5 + 5$ spines, of which the second is much the longest; posterior margin protuberant between the two large spines.

Eyestalk much shorter than eye, together less than one-third length of body. Peduncle of antennule rather short and stout, one-fifth length of body, with pointed stylocerite; flagella about $2\frac{1}{2}$ times as long as peduncle, the outer one thickened at the base.

Antennal scale five times as long as wide, with large terminal spine. Palp of maxillule with three setae, unsegmented. Exopod of maxilla very large and broad anteriorly; endopod unsegmented and without distinct inner lobes; endites well developed. Maxillipede 1 exopod with eight pairs of distal setae and enlargement at base bearing nine setae; endopod of four segments; coxa large, with long setae; epipod large. Maxillipede 2 ischium and merus, and propod and dactyl fused; epipod large. Legs 1 and 2 chelate, carpus of leg 2 long and slender. Leg 3 with propod slightly expanded. Leg 4 propod very much expanded, about twice as long as wide; exopod present. Leg 5 very long; ischium and merus fused and together $1\frac{1}{2}$ times as long as carpus; propod $1\frac{1}{4}$ times as long as carpus, and about twice as long as wide; pleopods large.

Measurements of legs (in mm.)

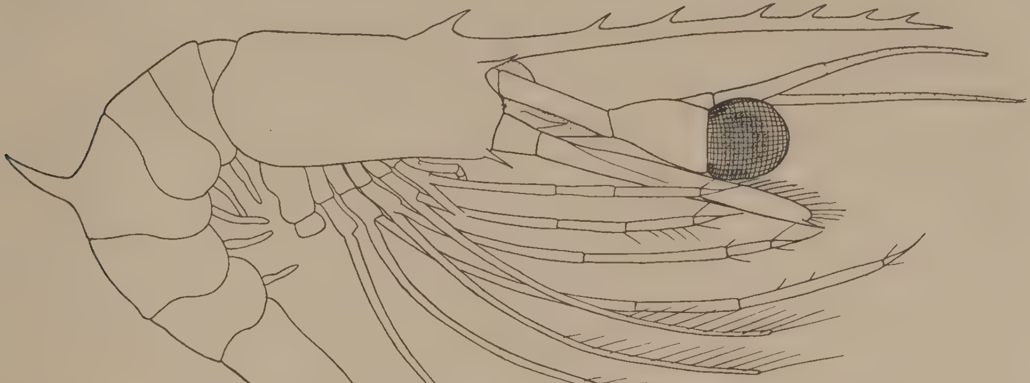
Leg	Propodus	Carpus	Ischio-merus
1	0·55	0·7	1·06
2	0·3	1·6	1·8
3	1·4 × 0·34	1·16	2·25
4	1·5 × 0·75	1·26	2·5
5	4 × 2	3·15	4·89

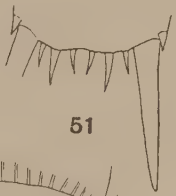


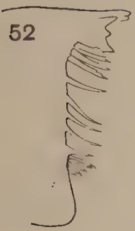
Eretmocaris. Species A. IV.

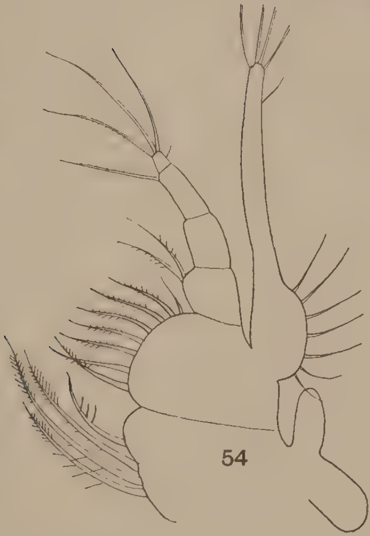
Fig. 42. Species A. IV.
Fig. 43. Species A. IV, telson.
Fig. 44. Species A. IV, mandible.
Fig. 45. Species A. IV, maxillule.
Fig. 46. Species A. IV, maxilla.
Fig. 47. Species A. IV, maxillipede 1.
Fig. 48. Species A. IV, part of leg 1.
Fig. 49. Species A. IV, leg 4 propodus.

A single specimen of this remarkable form was taken by Dr Wheeler just before my visit to Bermuda. A number of red chromatophores were still visible, as shown in Fig. 42.









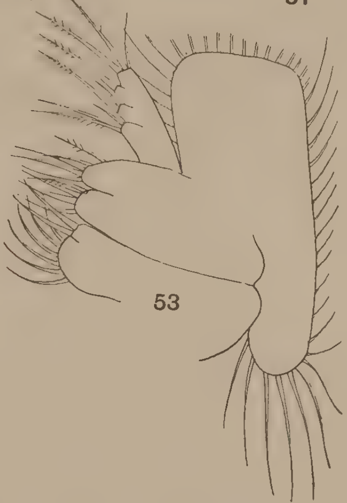


Fig. 50. *Eretmocaris*. Species A. V.
Fig. 51. Species A. V, end of telson.
Fig. 52. Species A. V, mandible.
Fig. 53. Species A. V, maxilla.
Fig. 54. Species A. V, maxillipede 1.

Species A. V (Figs. 50–54)

Eretmocaris corniger Bate, 1888, p. 900, pl. 145.
E. corniger Ortmann, 1893, p. 79.
St. 690. 03° 17′ S, 29° 57′ W. One specimen.
St. 701. 14° 39′ N, 25° 51′ W. One specimen.

Length of rostrum 3·1 mm.; of body 6·7 mm.

Rostrum very long and slender, with six dorsal teeth. Carapace with large dorsal tooth and supra-orbital and pterygostomial spines; antennal spine very small. Abdominal somite 3 with large, slightly procurved, dorsal spine; pleura rounded; somite 6 twice as long as deep.

Telson three times as long as wide, without lateral spines, and 5 + 5 terminal spines of which spine 2 is very large and the inner six quite small. No anal spine.

Eyestalk shorter than eye, together less than one-third of body length. Peduncle of antennule shorter than eye, less than one-quarter body length; flagella extending beyond rostrum. Antennal scale longer than eye; flagellum a little longer than scale.

Exopod of maxilla very broad and square in front; endopod with three distinct inner lobes, unsegmented; four endites well developed.

Maxillipede 1 endopod of four segments; coxa large, bearing long setae; exopod with five terminal setae, and basal enlargement bearing seven setae; epipod large, bilobed.

Legs 1 and 2 not chelate. Leg 4 with exopod, endopod lost. Leg 5 lost, but with enlarged base.

Pleopods present, small.

Bate's specimen had the rostrum broken, but Ortmann describes his as having it as long as the antennular flagellum, and with eight dorsal teeth, including the tooth on the carapace. Both specimens came from the neighbourhood of Cape Verde. The Discovery specimens are from much farther south and west, and far out in the ocean.

Species **A. VI** (Figs. 55–59)

Eretmocaris dolichops Ortmann, 1893, p. 79, pl. v.
St. 689. 05° 59′ S, 29° 49′ W. One specimen.

Length 11·6 mm.

Rostrum small and slender, without teeth. Carapace with dorsal papilla; no supra-orbital spine; anterior margin produced into a pointed process above antenna, and lower margin with four teeth. Abdomen without spines, but pleura of somites 3–5 narrowing and rather acute; somite 6 about three times as long as deep.

Telson $3\frac{1}{2}$ times as long as wide, without lateral spines; apex with 4 + 4 spines.

Eyestalks extremely long, divided by a constriction into two segments, of which the first is the shorter; eye not distinctly marked off from stalk, together nearly as long as the body.

Peduncle of antennule about one-quarter length of body; flagella longer than peduncle. Antennal scale shorter than peduncle of antennule; flagellum more than three times as long as scale. Maxillule, palp unsegmented, with five setae. Exopod of maxilla very large, extending far beyond endopod, rather narrow in front.

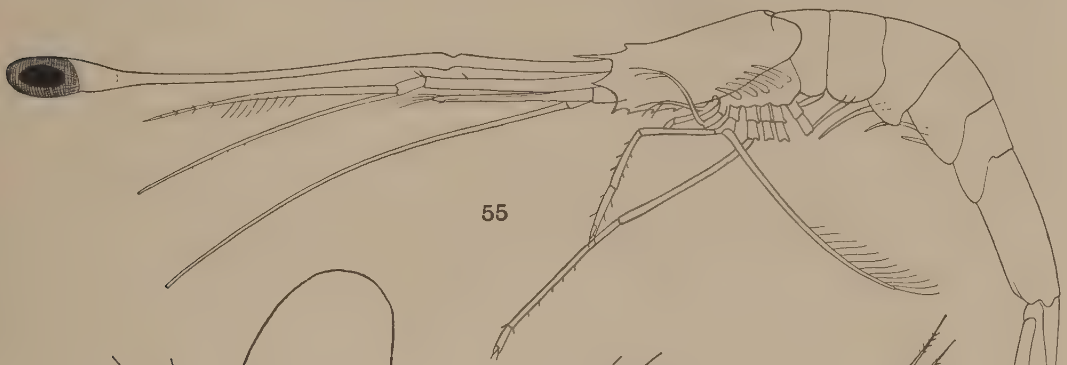
Maxillipede 1 endopod of four segments; exopod with eight terminal setae, and very slight basal enlargement bearing two setae; epipod large, bilobed.

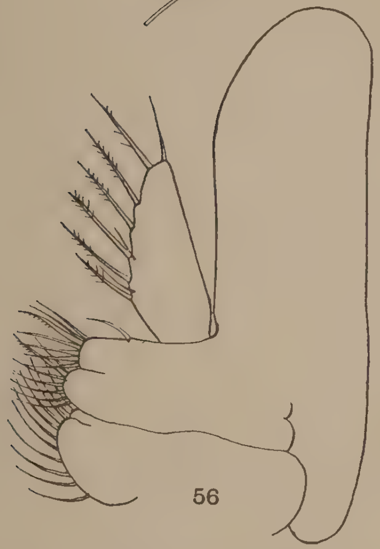
Maxillipede 2, endopod of four segments; epipod with rudiment of podobranch.

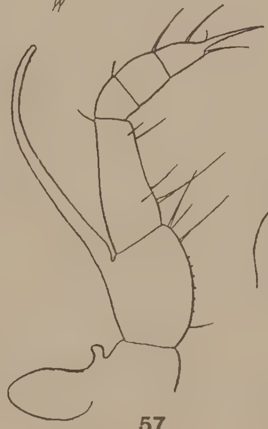
Legs 1 and 2 chelate; carpus of leg 2 very long and slender. No trace of epipods or arthrobranchs on legs. Legs 3–5 lost, but leg 4 apparently with exopod. Base of leg 5 not so large as that of leg 4, so that the leg is probably not enlarged.

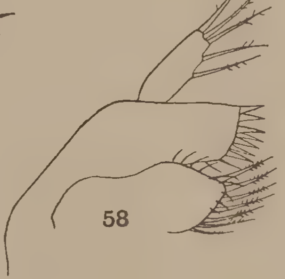
Pleopods slender.

This must be the same form as that described by Ortmann, but it differs in having the first segment of the eyestalk only about half the length of the second, whereas Ortmann describes it as about equal. *E. longicaulis* Bate is a very similar form, with the eyestalk enormously long, and with pointed abdominal pleura; but the eyestalk is not jointed, and it appears that leg 5 must be much enlarged.









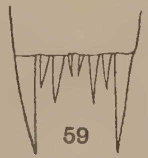


Fig. 55. *Eretmocaris.* Species A. VI.

Fig. 56. Species A. VI, maxilla, setae of exopod omitted.

Fig. 57. Species A. VI, maxillipede 2.

Fig. 58. Species A. VI, maxillule.

Fig. 59. Species A. VI, part of telson.

Species **A. VII** (Figs. 60–62)

St. 97. 33° 11′ S, 16° 55′ E. One specimen.

Length 10 mm.

Rostrum very small, upturned, without dorsal tooth. Carapace without dorsal tooth, and with supra-orbital, antennal and pterygostomial spines. Abdominal somites 1–4 with dorsal spines, pleura rounded.

What is perhaps the most important character, namely, the precocious appearance of leg 5, cannot, of course, be used when only isolated specimens of older stages are available, but it may prove that in all cases in which leg 5 has the same predominance over leg 4 it appears before it. Applying these characters, so far as is possible, to the forms here described it seems that the following may with some probability be assigned to *Lysmata*; Species R.S. II; B.R. I, II, III; A. I, II, III. Species A. I is evidently congeneric with the form referred to *Hippolysmata* by Kemp. In his form the rostrum had a series of small teeth at the base, and resembled that of some specimens in post-larval stage I which could be determined as *H. ensirostris*, and were taken at the same time off the Orissa coast. It may be accepted, then, that the larva of *Hippolysmata* does not differ strikingly from *Lysmata* in late stages; but we do not know the early stages, and it may be that there is a difference in the time of appearance of leg 5. It is unfortunate that I have no late stages of my form R.S. I which so closely resembles *Lysmata*, but differs remarkably in the late appearance of leg 5. It is not impossible that this may be the larva of *Hippolysmata multiscissa*, and that the genera may be distinguished by the order of appearance of the legs. There cannot be any doubt that R.S. I is at least closely related to *Lysmata*, and I refer it provisionally to *Hippolysmata*. Although the spine on the eyestalk is perhaps the most striking feature of Kemp's larva, and of A. I, I do not think it is such a character as must necessarily be found in all species of the genus. Kemp's figure shows that legs 1–4 are quite normal, and do not have the propod dilated.

Of the remaining four species from the Atlantic A. IV from Bermuda differs from the *Lysmata* type only in having the propodus of legs 3 and 4 dilated, and that of leg 5 is of unusually broad form; there is still the same discrepancy in actual length between legs 4 and 5. How far such a difference can be regarded as generic it is impossible to say. In the closely allied species *Caridion gordoni* and *C. steveni* (Lebour, 1930) the larvae differ in the presence or absence of large procurved spines on the carapace, and also in the greater or less expansion of the propod in certain appendages, and we do not know enough to exclude the possibility of large differences between species in *Lysmata* and *Hippolysmata*. It seems best to regard this form also provisionally as within one of these two genera.

The other three larvae differ so much from *Lysmata* that they cannot possibly be included in it or in *Hippolysmata*.

Species A. V has still the same general form, with long eyestalk and, presumably, enlarged leg 5, and its genus must be sought within those allied to *Lysmata*. The following genera are generally regarded as forming the Latreutid group of Hippolytidae:

Latreutes Stimpson.
Tozeuma Stimpson.
Trachycaris Calman.
Gelastocaris Kemp.
Bythocaris Sars.
Mimocaris Nobili.
Paralatreutes Kemp.
Lysmatella Borradaile.
Lysmata Risso.
Hippolysmata Stimpson.
Merguia Kemp.

The larvae of *Latreutes* and *Tozeuma* are known, and they have no resemblance whatever to *Eretmocaris*.

Bythocaris need not be considered, as it is said to have no free larva. *Gelastocaris*, *Lysmatella*, *Merguia* are not known from the Atlantic; so that if the "Latreutid group" is a reality we are confined in speculation to *Trachycaris* and *Mimocaris*. That seems to be all that can be said.

The remaining two species, A. VI and A. VII, cannot be even approximately placed. The only character which A. VI has in common with *Eretmocaris* is the enormously long eyestalk, and this is also peculiar in being jointed. Leg 5 is probably not enlarged. Until something is known about its legs it is useless to speculate about its identity.

Larva A. VII, again, has extreme elongation of the eyestalk, but here it is known that leg 5 is not modified, and leg 4 has no exopod. Having regard to the characters of such Hippolytid larvae as are known, I regard it as most improbable that either of these larvae can be placed among the Hippolytidae at all, and the only suggestion that can be made is that they may be Pandalids. In *Chlorotocella*[1] there is great elongation of the eye, though without distinction between eye and stalk, and I have referred to Pandalidae (1924, p. 114) a larva which agrees with *Pandalus platyceros* in having the abdominal and carapace margins serrated, while the eyestalks are as much elongated as in some *Eretmocaris*.

This character alone cannot therefore be regarded as confined to the Latreutid group of Hippolytidae, and the genus *Eretmocaris* is an ill-founded composite of unrelated larvae.

THE GENUS *TOZEUMA* STIMPSON

I am indebted to Dr J. F. G. Wheeler for specimens of *Tozeuma carolinense* Kingsley in stage I which were hatched at Bermuda Biological Station on 30 May 1936. For these and other interesting specimens I would like to express my thanks to him.

STAGE I (Figs. 63–70). Length of rostrum 0·9 mm.; body 3·0 mm.; total length 3·9 mm.

Rostrum nearly twice as long as antennule, without teeth, rather deep, parallel-sided in side view as far as distal third where the lower margin slopes sharply upwards to end in an acute point. Carapace without supra-orbital spines; margin smooth, with small pterygostomial spines.

Abdominal somite 3 with large pointed dorsal process, curving slightly forwards; somite 5 elongated, with a pair of large lateral spines. Telson concave behind, the spines all of about the same length.

Antennule with very short feathered seta and four aesthetes on exopod. Of the aesthetes three are long and blunt-ended, one much stouter than the other two, and one is much shorter and pointed, apparently without the membrane seen in *Eretmocaris* R.S. I.

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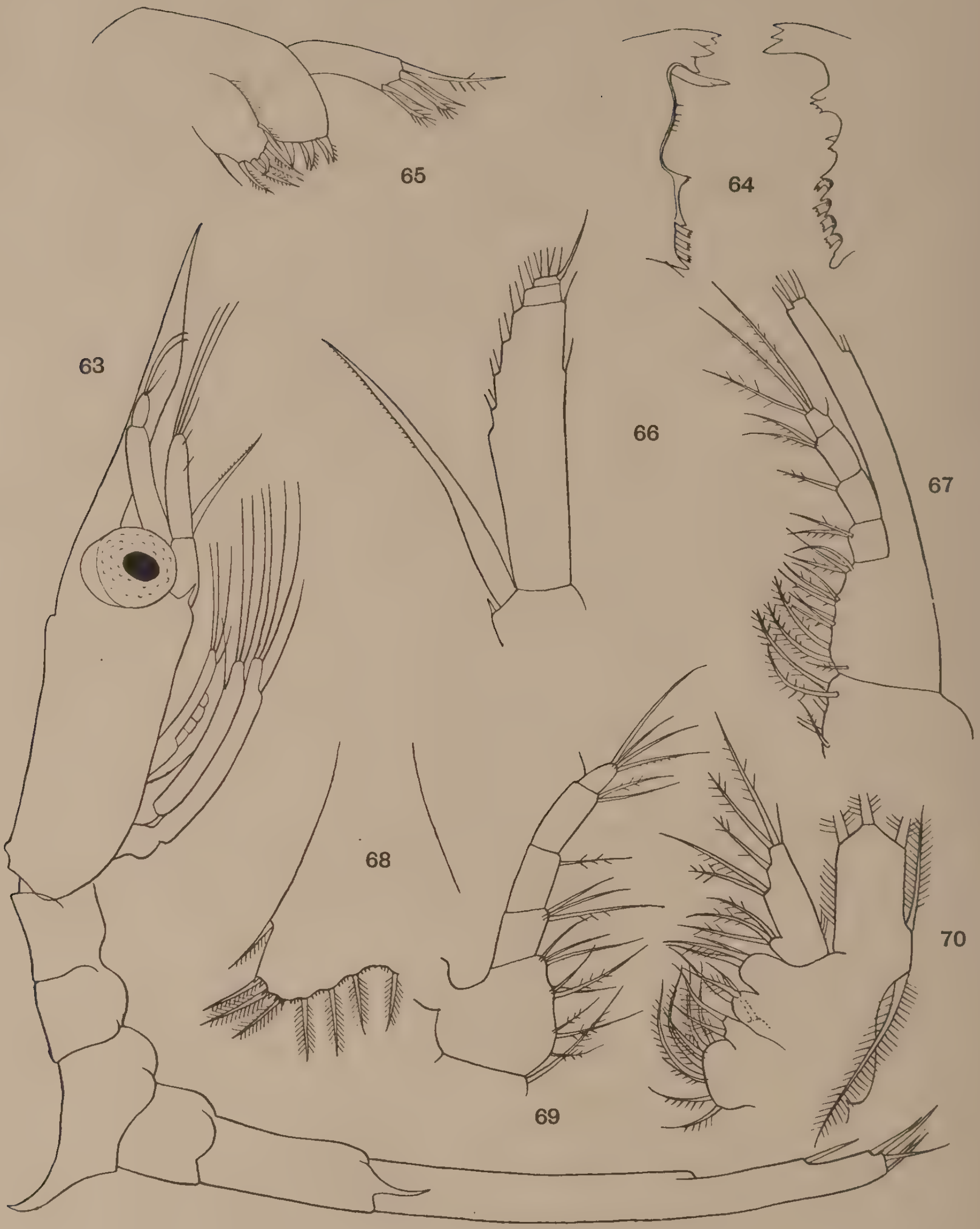
[1] Material from Ghardaqa, not yet published.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Tozeuma carolinense. Stage I.

Fig. 63. Stage I. Lateral.
Fig. 64. Mandibles.
Fig. 65. Maxillule.
Fig. 66. Antenna.
Fig. 67. Maxillipede 1.
Fig. 68. Telson.
Fig. 69. Maxillipede 2.
Fig. 70. Maxilla.

Antennal scale with two small outer setae and nine inner and terminal setae; with two distal segments traceable. Inner margin with slight protuberance before first seta. Endopod spine-like.

Maxillule, endopod unsegmented with five spines. Maxilla, exopod with five setae; endopod unsegmented, with three inner lobes bearing setae; apex with three setae.

Maxillipedes 1–3 each with endopod of four segments, and with apical setae of segment 4 long and slender; exopods with three apical setae; exopod of maxillipede 1 with one outer marginal seta, the other two with a pair of setae.

No later stages of this species are known; but I am indebted to Mr F. S. Russell for permission to describe later larvae belonging to two distinct species of *Tozeuma* taken in plankton from the Great Barrier Reef. One of these (species B.R. II) is represented by a single specimen, and is evidently the same as that described by Kemp (1916, p. 400) as the larva of *T. armatum*. In view of the fact that several species are known from Australian waters I do not feel justified in accepting so precise an identification.

Tozeuma species B.R. I

Of this form there are eight specimens apparently representing five stages, of which the youngest is certainly stage III, and the oldest probably stage VIII. Stage VII is not represented, and it is probable that there is also a ninth stage.

Stage III (Figs. 71, 72). Length of rostrum 2 mm., body 5·6 mm.; total length 7·6 mm.

Rostrum with two small ventral spines, broadening at base over eyes, with a spine on either side representing the supra-orbital spines. Abdominal somites very elongated; somite 1 with anterior projection overlapping carapace, but not produced, as in later stages, into a spine. Somite 3 with an enormous posterior process ending in a procurved hook; somites 5 and 6 with lateral spines. Anal spine absent. Telson large, deeply hollowed, with small lateral spine; spine 2 fused with angle of telson; spine 3 reduced to a small seta.

Peduncle of antennule segmented; endopod represented by a small tubercle bearing a seta. Antennal scale slender, unsegmented, with outer apical spine and thirteen setae; endopod spine-like, about three-quarters length of scale.

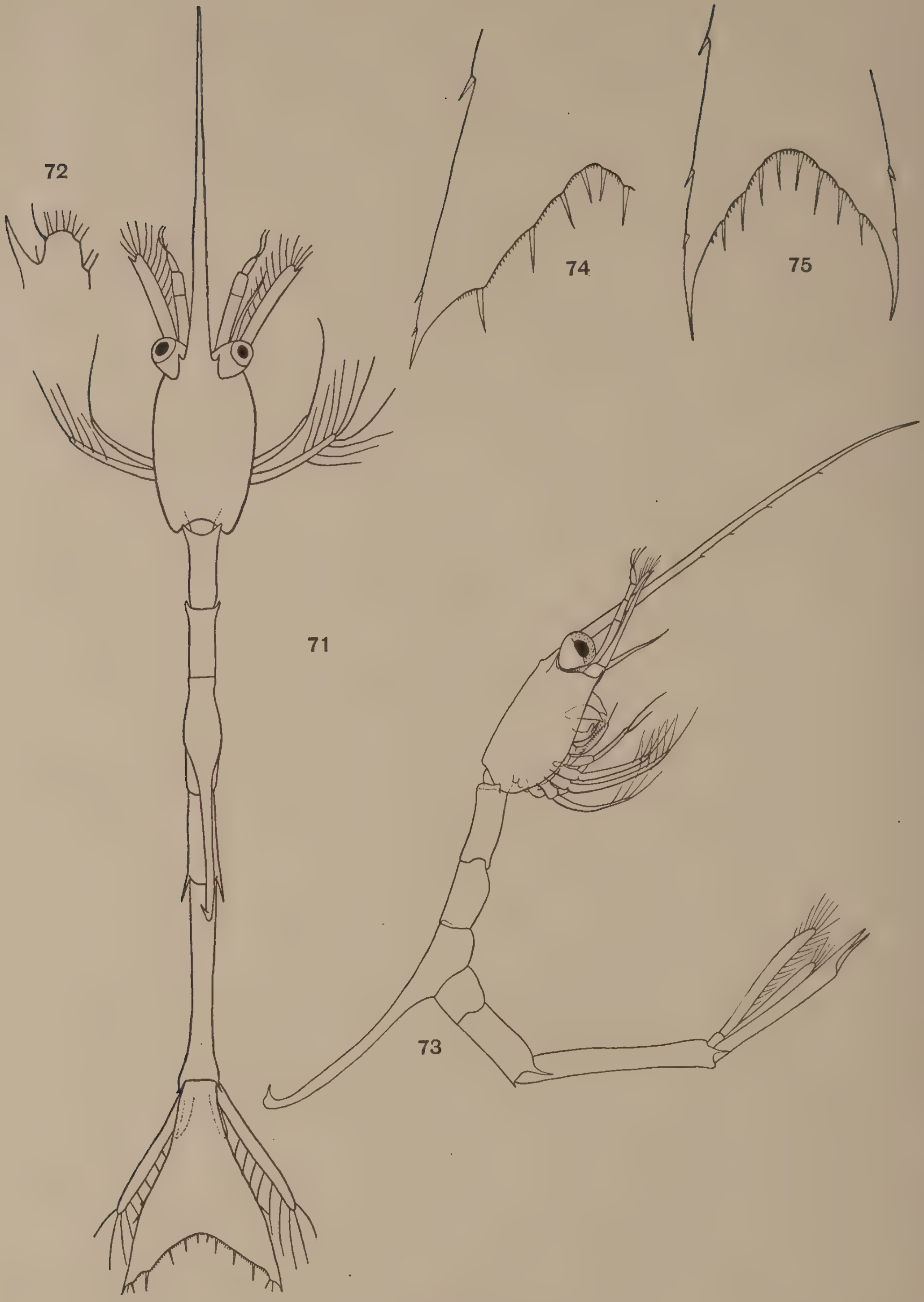
Exopods of maxillipedes 2 and 3 with eight and ten setae.

Legs 1 and 2 rudimentary, leg 1 fairly large and biramous.

Uropods with endopod rudimentary; exopod with nine setae.

Stage IV (Figs. 73, 74). Length of rostrum 4·0 mm., body 7·4 mm.; total length 11·4 mm.

Rostrum with three small ventral spines. Carapace with large supra-orbital spines and pterygostomial spines. Abdomen unchanged, but anterior overlapping part of somite 1 with sharp ventral angle, and somite 5 with very small posterior dorsal spine. Telson more deeply forked, with 8 + 8 small spines, of which three are on outer margin and the fourth forms the point of the fork.



Tozeuma B.R. I.

Fig. 71. Stage III. Fig. 72. Stage III, part of antennal scale. Fig. 73. Stage IV.
Fig. 74. Stage IV, telson. Fig. 75. Stage V, telson.

Endopod of antenna unchanged.

Leg 1 developed, its exopod with eight setae. Legs 3–5 rudimentary. Pleopods absent. Endopod of uropods nearly as long as exopod, with several setae.

STAGE V (Fig. 75).

Length of rostrum	6·0,	3·6 mm.
Body	9·3,	7·56 mm.
Total length	15·3,	11·16 mm.

The great difference in length between these two specimens suggests that two species may be represented, but they agree in all other respects, and differ very little from the preceding stage.

The telson is narrower, the limbs of the fork closing inwards (Fig. 75).

The anterior overlap of abdominal somite 1 has now a definite pointed process. The antenna is unchanged.

Legs 1 and 2 are developed, with exopods, and there are three pleurobranchs, the first, on leg 1, large and foliated, the third very small and rudimentary.

Pleopods absent.

STAGE VI. Length of rostrum 8·2 mm., body 11·05 mm.; total length 19·25 mm.

Abdominal somites 4 and 5 with small posterior dorsal spine.

Antenna unchanged. Legs 1–3 developed, with exopods. Five pleurobranchs, decreasing in size backwards to a small rudiment on leg 5.

No pleopods.

STAGE VIII? (Figs. 76–84). Length of rostrum 10·6 mm., body 14·7 mm.; total length 24·7 mm.

Rostrum with about sixteen small ventral spines. Abdominal somite 2 with small anterior spine on pleura. Telson very long and narrow (width : length about 1 : 6), deeply forked at end, with three pairs of large outer spines and four pairs on posterior margin. Anal spine present.

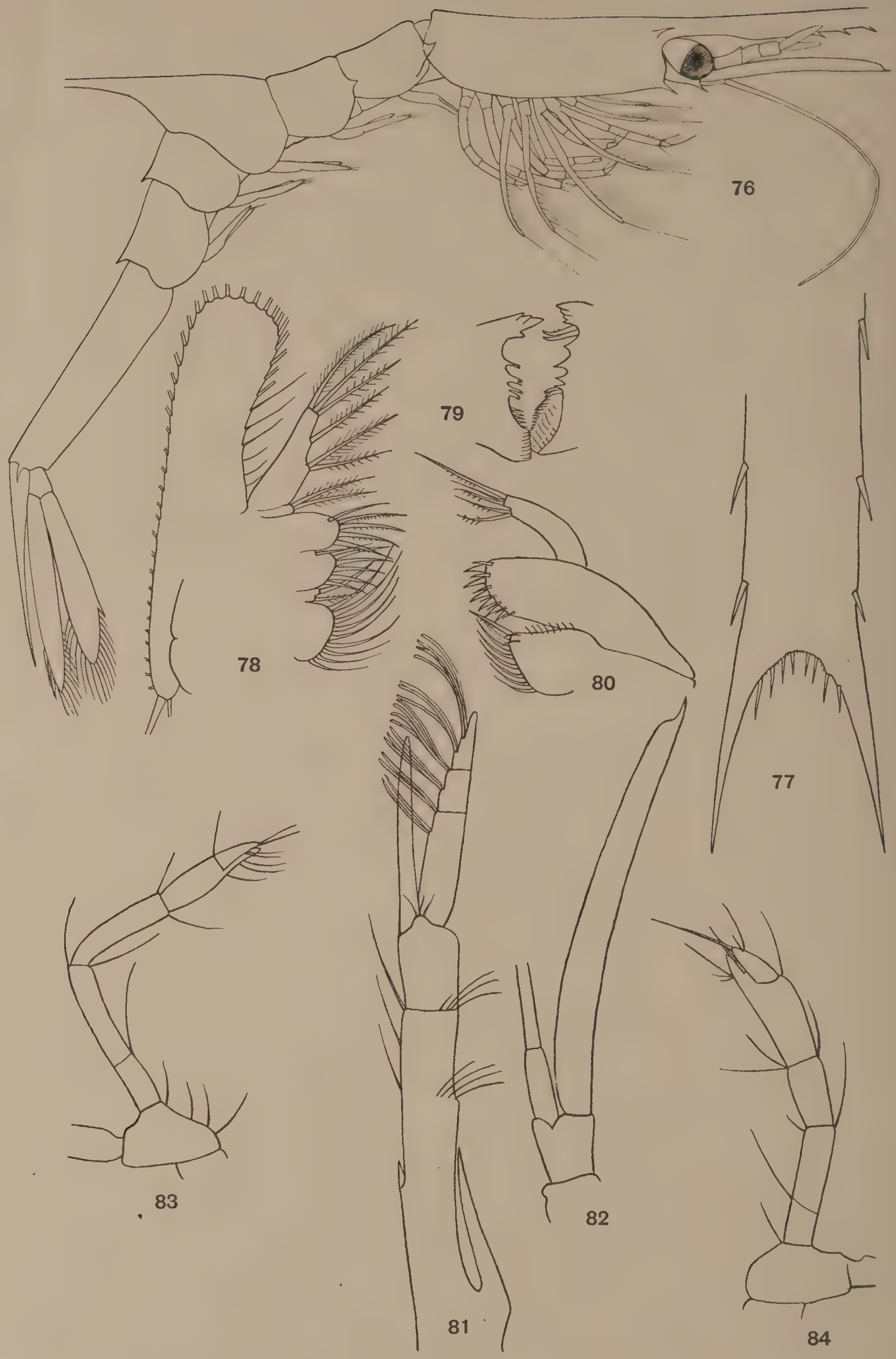
Antennule, exopod faintly segmented, with six groups of aesthetes; endopod shorter than exopod; segment 1 of peduncle with long pointed stylocerite and small ventral spine.

Antennal scale very long and slender, narrowed at end; flagellum very much longer than scale, with basal segment distinct.

Maxillule, palp unsegmented, with five spines. Maxilla, endopod with small basal segment marked off, distal part with six setae; exopod very large, extending beyond endopod, and broad and square at end.

Legs 1 and 2 chelate, leg 1 shorter than leg 2, dactyl shorter than palm. Carpus of leg 2 nearly as long as chela. Legs 4 and 5 without exopods.

Pleopods large, with small setae.



Tozeuma B.R. I.

Fig. 76. Stage VIII?.

Fig. 77. Stage VIII?, telson.

Fig. 78. Stage VIII?, maxilla.

Fig. 79. Stage VIII?, mandibles.

Fig. 80. Stage VIII?, maxillule.

Fig. 81. Stage VIII?, antennule.

Fig. 82. Stage VIII?, antenna (setae omitted).

Fig. 83. Stage VIII?, leg 2.

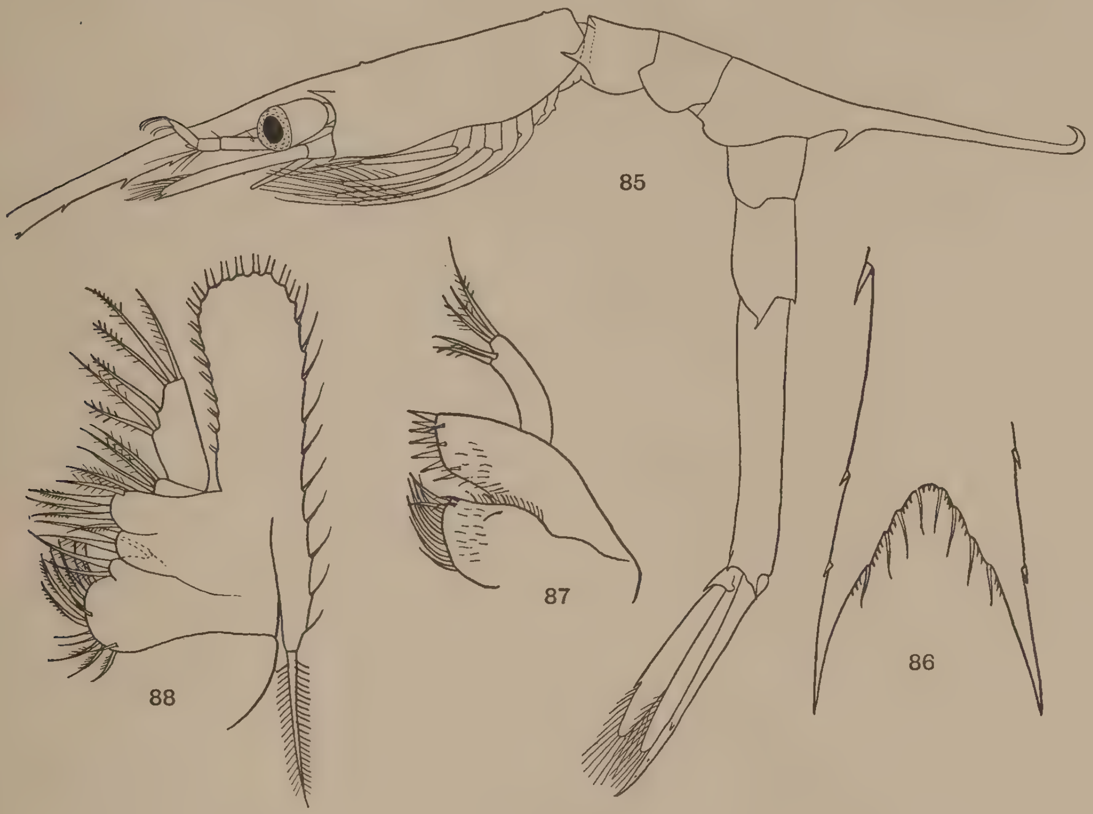
Fig. 84. Stage VIII?, leg 1.

Tozeuma species B.R. II

Stage VI? (Figs. 85–88). Length of rostrum 15·3 mm., body 10·8 mm.; total length 26·1 mm.

Rostrum with about twenty-five ventral spines; towards the end larger spines alternate with very minute spinules.

General form the same as in species I except for the immensely long rostrum and the dorsal process of abdominal somite 3, which has a large posterior spine at its base.



Tozeuma B.R. II.

Fig. 85. Stage VI?.
Fig. 86. Stage VI?, telson.
Fig. 87. Stage VI?, maxillule.
Fig. 88. Stage, VI? maxilla.

The specimen is somewhat more developed than stage VI of species I, though it has no pleopods, for the antennule has a small rudiment of the stylocerite and the flagellum of the antenna is a rod nearly half the length of the scale.

The telson is five times as long (median length) as it is wide anteriorly, deeply forked, with three pairs of lateral spines and four pairs within the fork. The mouth-parts are as in species I (Figs. 87, 88).

There can be little doubt that this is the same species as that figured by Kemp, and it may well be that it is the larva of *T. armatum*, since the posterior spine on the abdominal process may perhaps persist as the spine present on somite 3 in the adult.

Coutière (1905, p. 21) has described a larva, *Caricyphus acutus* Cout., which he gives reasons for identifying with *Tozeuma*. This supposition can now be dismissed, since his larva is totally unlike that here described, the identification of which cannot be doubted.

CHORISMUS ANTARCTICUS PFEFFER

The plankton collected by the 'Discovery' and the 'William Scoresby' in the neighbourhood of South Georgia contains larvae of three species of Caridea. Of these one cannot be identified; but the other two belong to *Crangon antarcticus* Pfeffer and *Chorismus antarcticus* Pfeffer, the former being the commoner of the two.

In *Chorismus antarcticus* the eggs are large, 1·7 × 1·3 mm. I have not seen any eggs at all near hatching, but in one specimen they were sufficiently far advanced for the structure of the embryo to be made out without much difficulty. Rudiments of the full number of appendages were present, and the telson could be seen to be deeply cleft and apparently with 7 + 7 spines. The telson of the first free larva differs both in shape and in number of spines, so that a more primitive form of telson seems to be retained in the embryo. It is usual in the Caridea for the embryonic telson to bear only six spines, and I am not certain that there is an exception in this case. More advanced material should be examined.

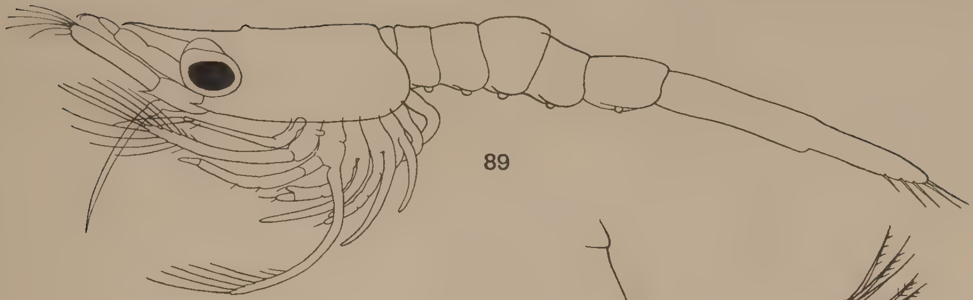
STAGE I. Length 6·6–7·5 mm. (Figs. 89–95).

Rostrum reaching end of antennular peduncle. Carapace with dorsal papilla and pterygostomial spine. Abdominal somites without spines. Telson slightly concave behind, with 10 + 10 spines. Peduncle of antennule unsegmented; endopod absent. Scale of antenna constricted at end, with one outer seta near end and eight inner and terminal setae crowded together; four distal segments indistinctly marked; flagellum longer than scale, with basal segment marked off; constricted at end into a short denticulate spine.

Palp of maxillule with five setae, unsegmented. Endopod of maxilla rather large, with three inner lobes; exopod large, with numerous setae, the seta at proximal end very large; four endites well marked.

Maxillipede 1, endopod of four segments; coxa large; epipod present, bilobed. Exopods of maxillipedes with three apical setae, those of maxillipedes 2 and 3 with twelve and fourteen lateral setae respectively. All legs present, large, legs 1–3 with exopods without setae. Legs 1 and 2 with rudimentary chelae. Five pairs of pleurobranchs present.

Pleopods absent, or present as very small papillae.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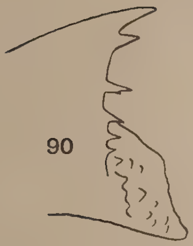
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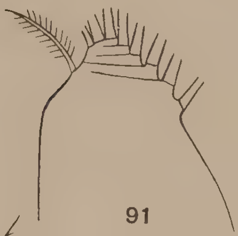
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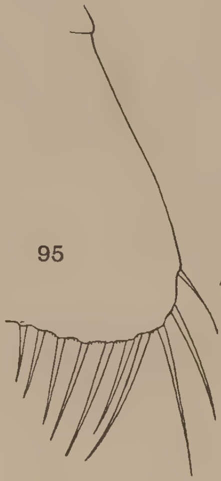
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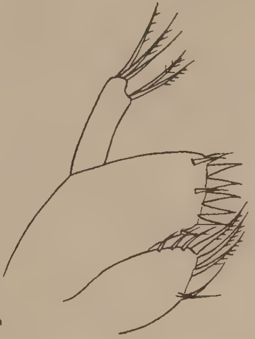
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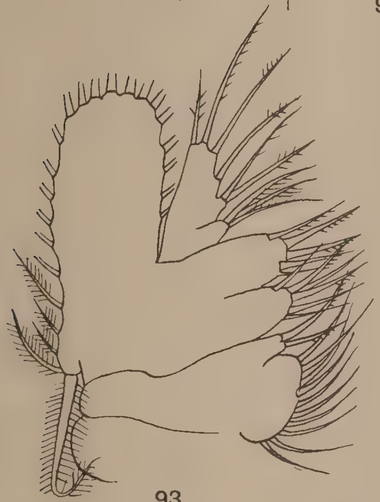
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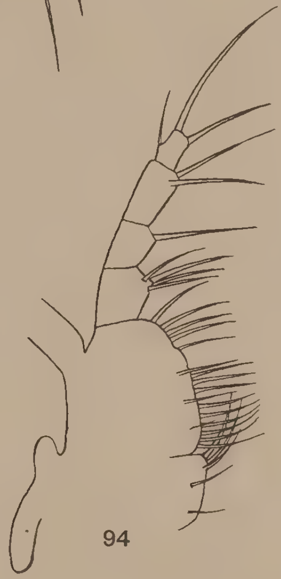
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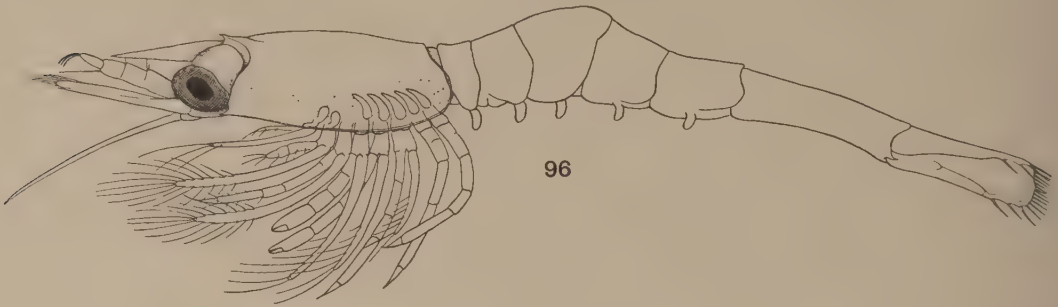
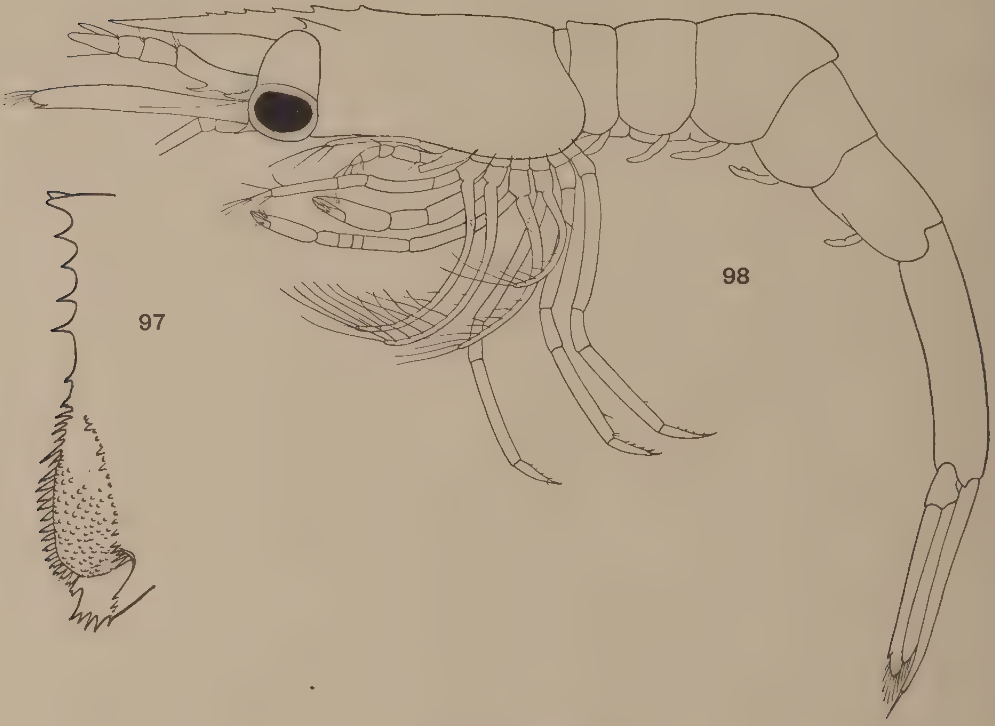
Chorismus antarcticus

Fig. 89. Stage I. Lateral.
Fig. 91. Antennal scale.
Fig. 93. Maxilla.
Fig. 95. Telson.
Fig. 90. Mandible.
Fig. 92. Maxillule.
Fig. 94. Maxillipede 1.

Stage II. Length 8–9 mm. (Figs. 96, 97).

Rostrum stouter, in some cases with three or four very minute dorsal teeth, but generally smooth. Carapace with supra-orbital spine. Telson marked off from somite 6 but with the same shape and number of spines. Anal spine present.





Chorismus antarcticus

Fig. 96. Stage II. Fig. 97. Stage II, mandible. Fig. 98. Stage III.

Antennule with peduncle segmented. Antennal scale unsegmented and with outer apical spine; flagellum longer than in stage I and without apical spine.

Legs much more developed, legs 1 and 2 with chelae; exopods of legs 1–3 with setae.

Pleopods present, small.

This stage differs very little from stage I, but can be most easily separated by the presence of a spine on the antennal scale.

STAGE III. Length 11 mm. (Fig. 98).

Rostrum a trifle longer than antennular peduncle; with five dorsal teeth and either smooth or with one small spine below. Telson with posterior margin straight; width at end more than half length (58 : 99), with 10 + 10 spines. Antennule with stylocerite, and with inner branch as long as outer, both unsegmented. Flagellum of antenna about 4 mm. Legs almost fully developed, legs 1 and 2 with large chelae. Carpus of leg 2 divided into four segments.

Exopod of maxillipede 1 not widened at base and without setae in this position. Epipods of maxillipede 3 and legs 1 and 2 absent in one of two specimens examined, but traceable in the other. No trace of arthrobranchs.

Pleopods large, without setae. Uropods fully developed.

Of sixty-nine seen only six were in this stage, which is no doubt the last larva.

POST-LARVAL STAGE I. Length about 16 mm. (Figs. 99–105).

Rostrum slender, not widening towards end, with 6–8 dorsal teeth and 3–4 ventral. Carapace without supra-orbital spine; with antennal and pterygostomial spines. Abdominal somites 3 and 4 slightly gibbous; pleura of somite 5 slightly pointed. Telson parallel-sided, about three times as long as wide, with two pairs of lateral spines and 12–16 slender spines on the slightly convex posterior margin. Anal spine large.

The appendages are all nearly of adult form. Mandible with small rudiment of palp. Carpus of leg 2 of eight segments.

Exopod of maxillipede 3 large, without setae. Legs 1–3 with large vestigial exopods. Gill formula and epipods as in adult, but no arthrobranch seen on maxillipede 3.

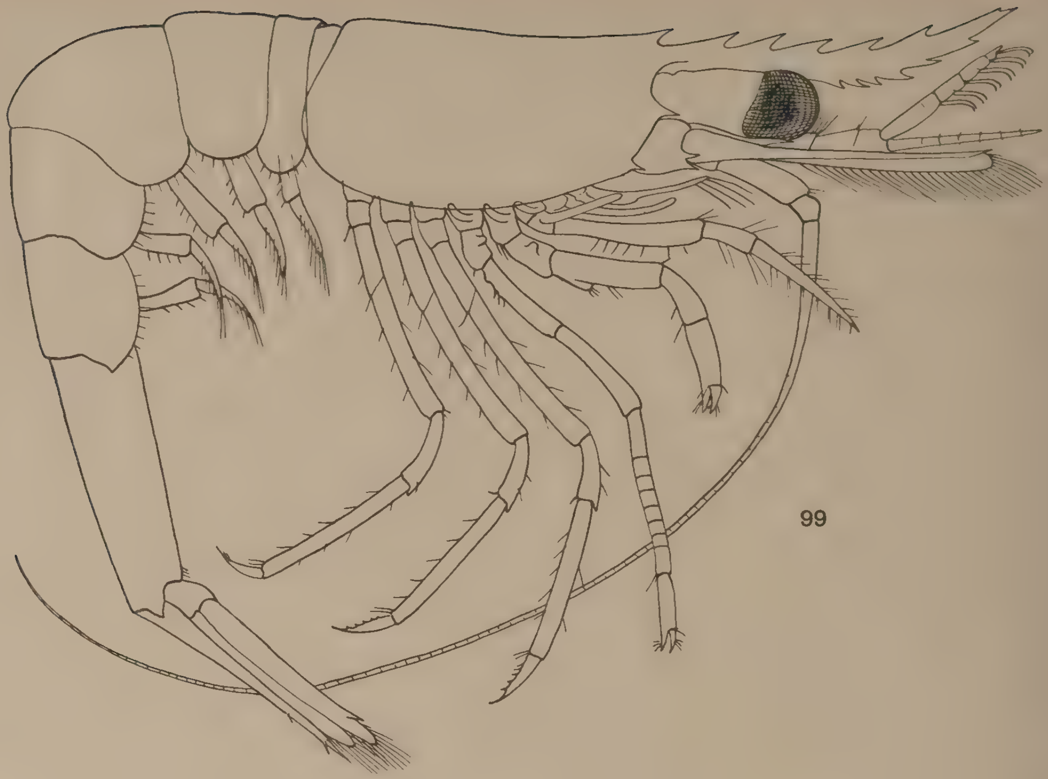
Some specimens differ in having no trace of an exopod on leg 3 and those of legs 1 and 2 reduced to small papillae, while somites 3 and 4 are not gibbous; but they are either of the same size, or but little larger, and do not seem to represent a second stage (Fig. 99).

Measurements of leg 2 (in mm.):

	Dactylus	Propodus	Carpus	Merus	Ischium
Last larva	0·23	0·39	0·71	0·49	0·45
Post-larval 1	0·27	0·43	1·2	1·0	0·9
Post-larval 2?	0·3	0·45	1·5	1·05	0·85

Coutière (1905, p. 26; 1907, p. 15) has suggested that the larva described by him as *Hippocaricyphus bigibbosus* may belong to *Chorismus*. The possibility that it might be *C. antarcticus* is now excluded, and it is most unlikely that the development of *C. tuberculatus* could differ so profoundly as Coutière's supposition would require. Coutière's larvae were taken at two stations in the central Atlantic,[1] a fact which, in itself, would seem to exclude their identification with a genus confined to the Antarctic.

[1] St. 1851, 36° 17′ N, 28° 53′ W; St. 2187, 38° 04′ N, 26° 07′ W.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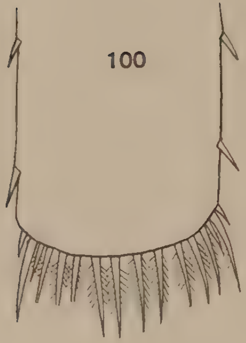
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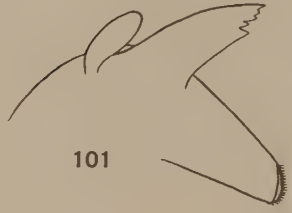
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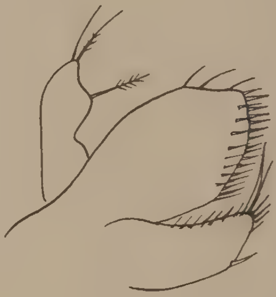
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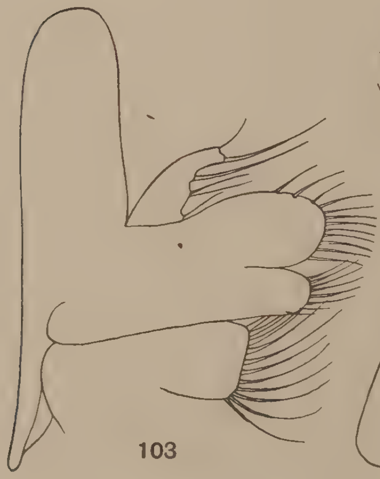
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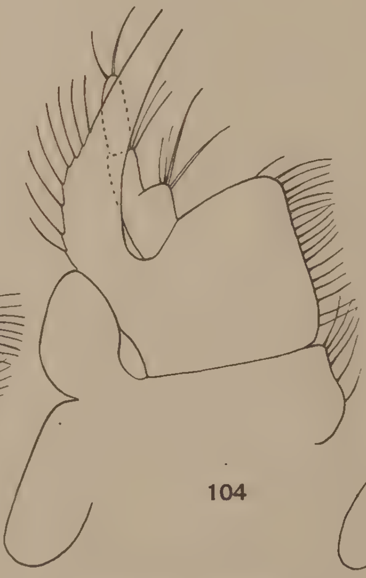
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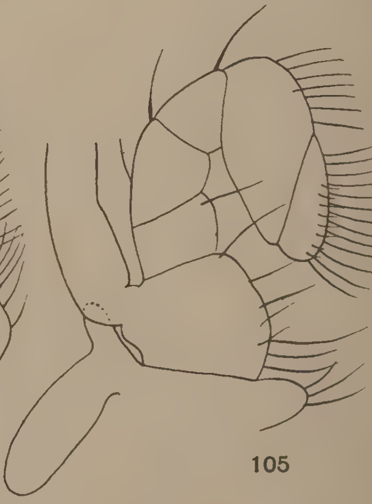
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Chorismus antarcticus

Fig. 99. Post-larval stage I?.
Fig. 100. Post-larval I, telson
Fig. 101. Post-larval I, mandible.
Fig. 102. Post-larval I, maxillule.
Fig. 103. Post-larval I, maxilla, setae of exopod omitted.
Fig. 104. Post-larval I, maxillipede 1.
Fig. 105. Post-larval I, maxillipede 2.

DISCUSSION

This species provides an interesting example of abbreviated development. In *Bythocaris* and *Cryptocheles* the free larva is entirely suppressed (Sars, 1885), the young hatching in the form of the adult. In *Spirontocaris polaris* the first free larva is much more developed than in *Chorismus antarcticus* and has lost all the characters distinctive of stage I (Stephensen, 1935).

In *Chorismus* the first larva, though it has the full number of appendages, retains certain characters of the normal first larva which one would think might well have been lost. For example the antennule is unsegmented and has no trace of the inner branch; the antennal scale has no spine, and retains traces of segmentation and few setae, while the flagellum, though so far developed, terminates in a denticulate spine, showing that it has developed from the spine-like form found in *Hippolyte* and *Spirontocaris* but not in *Caridion*. The exopods, although furnished with far more setae than is normal in stage I, have the apical setae arranged asymmetrically, as is usual in stage I in Hippolytidae and certain genera of other families of Caridea.

When development is shortened it is commonly the case that the telson has more than the normal number of spines (e.g. *Sabinea*, *Palaemon borellii*). Sollaud (1923) has already noted the retention of some of the characters of the normal stage I in Palaemonidae in which larval development is greatly shortened or suppressed, and particularly that the telson retains the wide triangular form until transformation to the adult.

Distribution of larvae of Chorismus antarcticus

Station no.	Position	Larvae	Post-larval
125	53° 28′ S, 36° 20′ W	3	—
127	53° 48′ S, 37° 08′ W	1	—
130	54° 06′ S, 36° 23′ W	2	—
134	54° 22′ S, 35° 56′ W	49	—
135	54° 22′ S, 35° 39′ W	1	—
540	62° 06′ S, 55° 08′ W	1	—
541	62° 22′ S, 55° 23′ W	1	—
544	62° 26′ S, 57° 15′ W	1	—
546	62° 46′ S, 57° 11′ W	1	—
WS 18	54° 07′ S, 36° 23′ W	1	—
WS 19	54° 00′ S, 36° 20′ W	1	—
WS 20	53° 52′ S, 36° 00′ W	1	—
WS 33	54° 59′ S, 35° 24′ W	1	—
WS 42	54° 41′ S, 36° 47′ W	1	1
WS 47	54° 22′ S, 37° 50′ W	2	—
WS 48	54° 24′ S, 38° 09′ W	2	—
WS 243	51° 06′ S, 64° 30′ W	—	1
MS 67	S. Georgia, E. Cumberland Bay	—	2
MS 71	”	—	13
MS 74	”	—	2
Total		69	19

In *Spirontocaris polaris* the first larva has the antennule fully segmented, with small inner branch; the antennal scale has the apical spine, and no segmentation; supra-orbital spines are present; the exopods of the maxillipedes (they are absent from all legs) have four symmetrically placed apical setae (Stephensen).

The most remarkable feature of shortened development is the apparent difficulty of eliminating the three first obligatory stages of the normal larva. In normal development the uropods appear almost without exception in stage III, and, however fully the free larva is provided with pereiopods, or even pleopods, when hatched, the uropods are never present. In the few cases in which the course of abbreviated development is satisfactorily known the uropods appear, as in the normal larva, in stage III even if the adult form is to be attained at the next moult—for example, *Palaemonetes varians lacustris*, *Palaemon potiuna* (Sollaud, 1923). Even more striking is the fact that in *Astacus fluviatilis*, although the young on hatching have all the appendages more or less of adult form, still the uropods do not appear till stage III. In *Sclerocrangon*, although the young hatch in the adult form, and attach themselves to the parent, the embryo just before hatching has no uropods (Wollebaek, 1906).

SARON MARMORATUS (OLIVIER) AND ALLIED FORMS

Saron marmoratus is not uncommon on the coral reefs at Ghardaqa, and two females hatched their eggs in the laboratory. A close similarity was at once noticed between these larvae and others which were at the time common in the plankton, and it was assumed at first that all belonged to this species. They were all characterized by their rich colour, generally red, and compact form, with small posterior tooth on the carapace. It was not possible to spare the time necessary for detailed examination, but it became evident later that there must be at least two species present, though they could not be easily distinguished without risk of injury to those which it was desired to keep alive. I was also singularly unfortunate in getting these larvae to moult to post-larval. Examination of the preserved material shows that there are actually at least three distinct forms, and that the material does not admit of separating them into series. It is also impossible to determine with sufficient certainty that any of the later larvae belong to *Saron*.

The close resemblance of these larvae to *Latreutes* (Gurney, 1936) is evident, but they all lack the dorsal spines present on abdominal somites 4 and 5 in *L. fucorum*, and also the spine present in that species in the middle of the margin of the carapace. They agree in general form, in shape of telson and in the presence of a small tooth at the posterior angle of the carapace. Further, the fact that in all these forms there are four apical setae on the exopods is an important point when we take into account the fact that there are three in all other Hippolytidae known. I have given below a description of a larva from the Barrier Reef which I attribute with some doubt to *Latreutes*, for the sake of comparison with the Red Sea larvae.

It is quite certain that these larvae all belong to closely related species of Hippolytidae, though it is impossible to identify them, and it may well be that *Latreutes* is among the forms from the Red Sea.

In view of the doubtful relations between the various genera of the Hippolytidae further study of this well-defined group of larval forms would be useful, and the problem of their identity would be easily solved at Ghardaqa if it could be attacked at a rather later season than that of my own visit, and with better opportunities for getting plankton.

Saron marmoratus (Olivier)

STAGE I. Length 2·5 mm. (Figs. 106–112).

Carapace with small pterygostomial spine and two anterior marginal teeth; anterior and posterior papillae present, small; ventral margin sinuate, with small tooth at posterior angle; rostrum absent. Pleura of abdominal somite 2 pointed, the rest rounded; without dorsal or dorso-lateral spines. Telson rather narrow, with 7+7 spines.

Exopod of antennule with inner feathered seta long, and four aesthetes, of which one is slender and pointed, with a narrow hyaline margin. Antennal scale short and broad, with two outer setae and ten inner and terminal setae; four terminal segments distinct; endopod spine-like. Maxillule without outer seta on basis; endopod unsegmented, with five setae. Endopod of maxilla segmented, with basal lobe very well marked; lacinia 2 large; exopod with five setae.

Exopods of maxillipedes 2 and 3 with six setae, the four apical setae symmetrically placed.

Rudiments of legs 1 and 2 biramous.

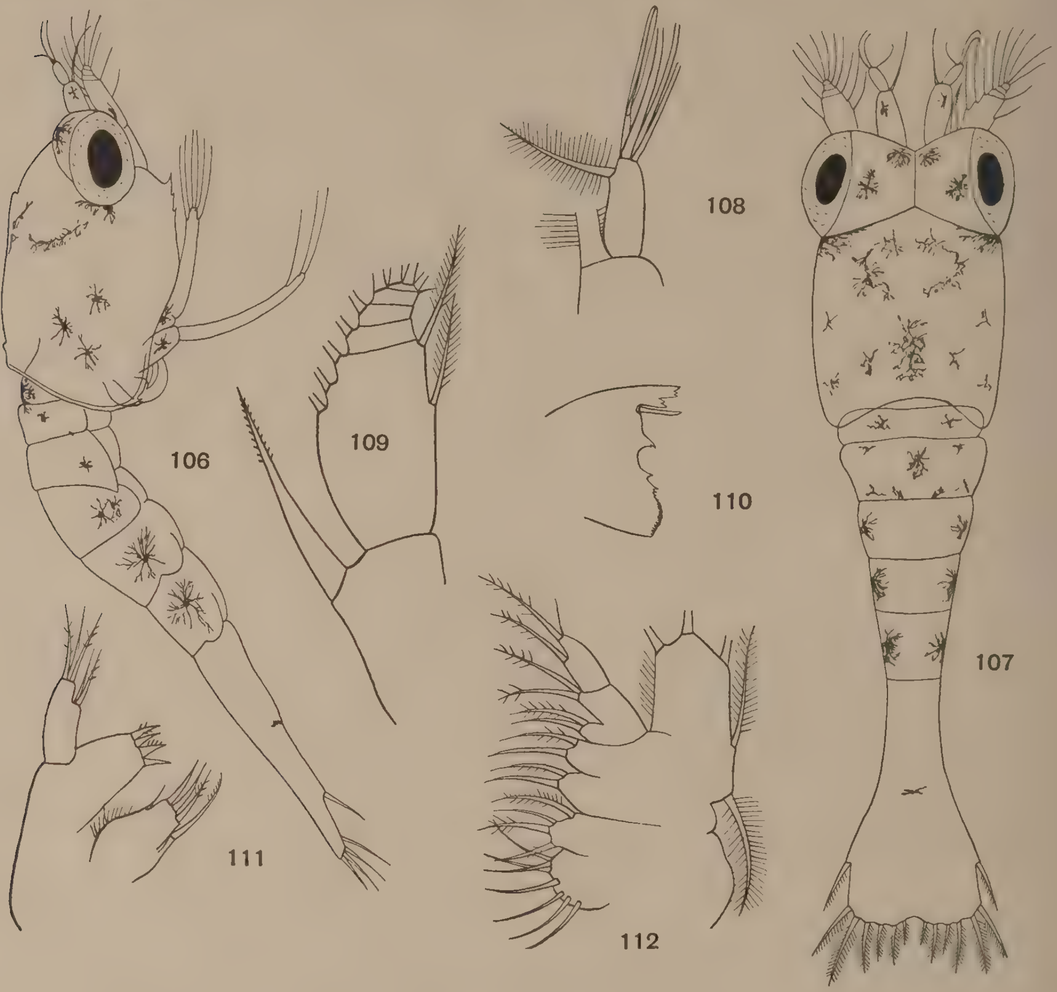
General colour very red, with many deeply placed red chromatophores. When these are contracted a pale yellow tinge remains general.

As I supposed at the time that the *Saron* larvae were hatched that the larvae found in the plankton belonged to the same species, no attempt was made to keep the larvae through a moult. I find it now impossible to be sure which, if any, free larvae belong to *Saron*. There is a species which has the pleura of the abdomen of the shape characteristic of *S. marmoratus*, but there is also another form of stage I which is like *Saron*, but has a small downturned rostrum, which *Saron* has not. There are therefore apparently three species. One which is described below is quite distinct by reason of its large rostrum and the shape of the abdominal pleura, but the others cannot be satisfactorily dealt with. One specimen in the last stage moulted to post-larval and should have given the opportunity of identifying its genus, but this specimen was lost by accident before the essential characters had been made out. I give, therefore, only a description of a stage II larva which I believe to be *Saron*, and leave the rest undescribed.

STAGE II. Length 3·3 mm.

Rostrum shorter than antennule, triangular in dorsal view, and very slender in side view. Carapace without supra-orbital spine; with large pterygostomial spine and an anterior process extending under the eye. Abdominal somite 2 with pleura large and pointed, the rest rounded.

Antennule with base widened, and rudiment of stylocerite. Antenna, basis with small ventral spine; endopod short, with small apical spine; scale constricted at end, with traces of segmentation. Exopod of maxilla with large proximal setae; eleven setae in all.



Saron marmoratus

Fig. 106. Stage I, dorsal.
Fig. 107. Stage I, lateral.
Fig. 108. Stage I, antennule, part.
Fig. 109. Stage I, antenna.
Fig. 110. Stage I, mandible.
Fig. 111. Stage I, maxillule.
Fig. 112. Stage I, maxilla.

Exopod of maxillipede 1 with outer seta at base and five apical setae; coxa large; endopod of four segments without outer setae; epipod large, not bilobed.

Exopods of maxillipede 3 and legs 1 and 2 with six setae.

Legs 3–5 rudimentary; leg 3 large and biramous.

Three rudimentary pleurobranchs present.

Pleopods and uropods absent.

Hippolytidae, Species R.S. I.

Stage I. Length 3·9 mm. (Figs. 113, 114).

Rostrum large, extending beyond antennules. Carapace as in *Saron*, with small posterior tooth and anterior spine and marginal teeth. Pleura of abdominal somites 2–5 pointed. Telson narrow, as in *Saron*.

Antennal scale a little broader than in *S. marmoratus*; endopod stout at base and constricted at end into a denticulate spine.

Exopods of maxillipedes 2 and 3 with four apical setae.

Rudiments of legs 1–5 traceable.

Stage II. Length 4·3–4·8 mm. (Figs. 115–117).

Rostrum large, broadening at base over eyes. Carapace without supra-orbital spine; with large, bluntly pointed, process under eye. Telson unchanged except for additional inner pair of spines. No anal spine.

Antennule stout, peduncle segmented, with ventral spine, and slightly enlarged at base with trace of stylocerite. Antennal scale with segmentation still traceable, and 17 inner and terminal setae; endopod stout with basal segment marked, and small terminal spine; basis without spine.

Legs 1 and 2 with incipient chelae; legs 1–3 with exopods bearing 8.6.6 setae; legs 4 and 5 rudimentary, leg 4 with rudiment of exopod. Pleopods present as small buds. Rudiments of pleurobranchs on legs 1–4.

The description is taken from a specimen moulted from stage I.

Stage III. Length 5·4 mm. (Figs. 118–121).

Telson nearly rectangular, slightly wider at end, the width about half the length; no lateral spines; terminal spines 7 + 7. Anal spine absent.

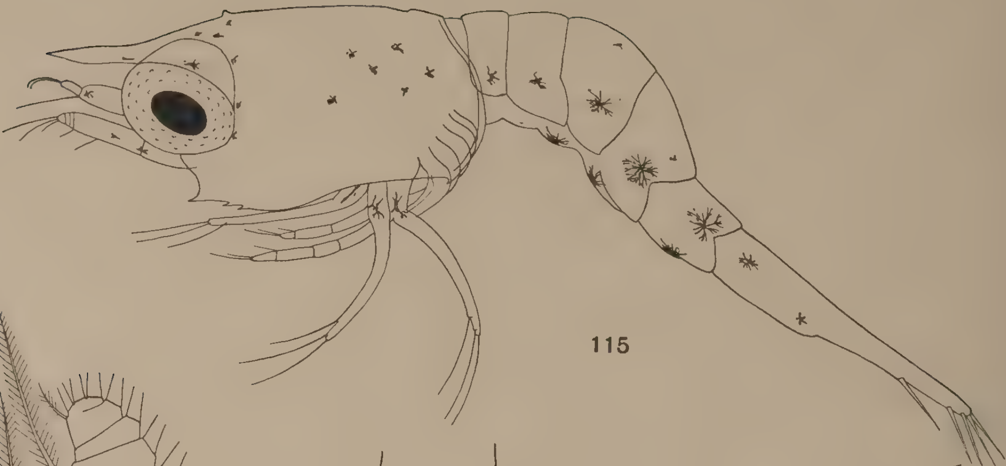
Antennule with small stylocerite; exopod with feathered seta and aesthetes in three groups, but not segmented. Antennal scale unsegmented, without outer setae and generally without outer apical spine. A very small spine seen in one specimen (Fig. 120). Endopod nearly as long as scale.

Legs 1 and 2 subchelate, leg 4 with exopod. Pleurobranchs large; rudiments of epipods on maxillipede 2 and legs 1–4. Pleopods bilobed. Uropod, exopod with 14 setae; endopod small, not jointed to basis, with two small apical setae.

To show how very much alike these different species of red carid larvae are I give a figure (Fig. 122) of a second species, in stage IV, which can be distinguished by the form of the rostrum and shape of the abdominal pleura.

Stage IV. Length 5·3–6·7 mm. (Figs. 123–128).

Rostrum in some cases with two small ventral teeth and one dorsal; carapace unchanged, but with very small tooth in front of anterior dorsal papilla. Telson nearly or quite three times as long as wide, narrowed at end, without lateral spines, and with 5 + 5 terminal spines. Anal spine absent. Antennule with stylocerite but no trace of



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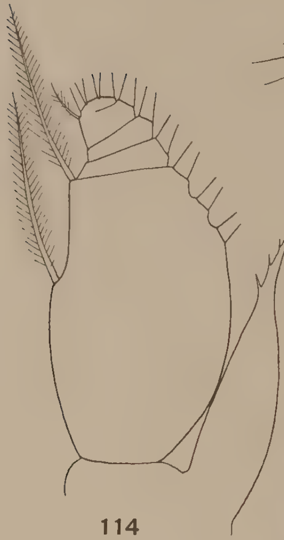

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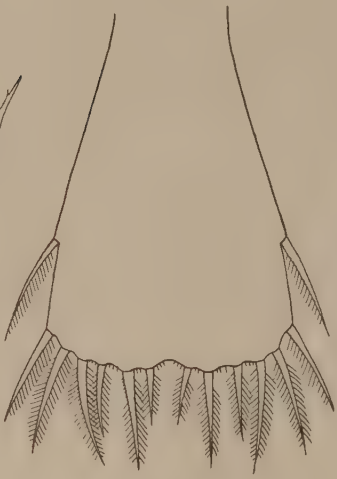

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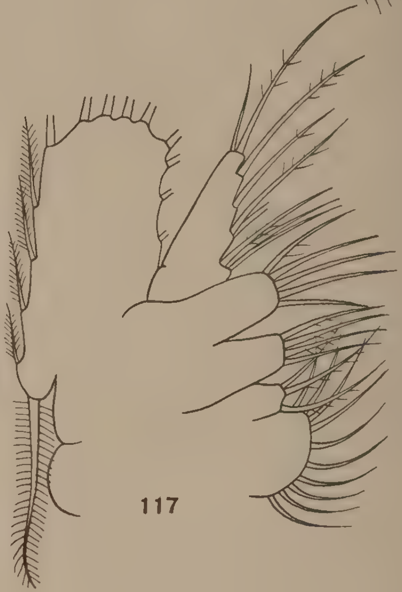

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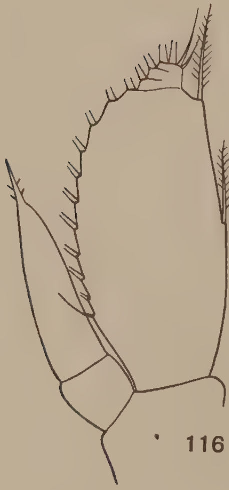

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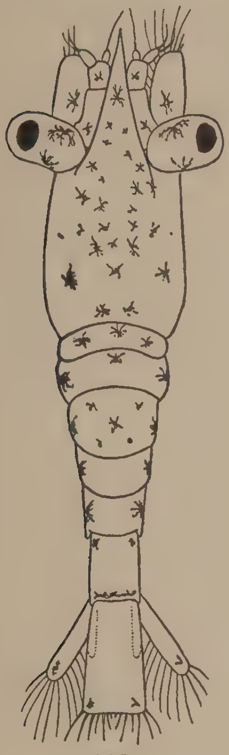
Hippolytid R.S. I.

Fig. 113. Stage I, telson. Fig. 114. Stage I, antenna. Fig. 115. Stage II, lateral.
Fig. 116. Stage II, antenna. Fig. 117. Stage II, maxilla.

otocyst. Antennal scale without outer distal spine in all specimens seen; endopod as long as exopod, unsegmented.

Exopod of maxilla very narrow proximally, with one large seta at end. Maxillipede 1 with large epipod having a small anterior lobe which seems to be a rudiment of a podobranch; endopod segments 1 and 2 with outer seta; coxa large.

Legs 1 and 2 with large chelae; carpus of leg 2 undivided. Leg 4 with exopod bearing eight setae. Epipods present on legs 1–4. Pleopods large, without setae, but with rudiment of appendix interna.



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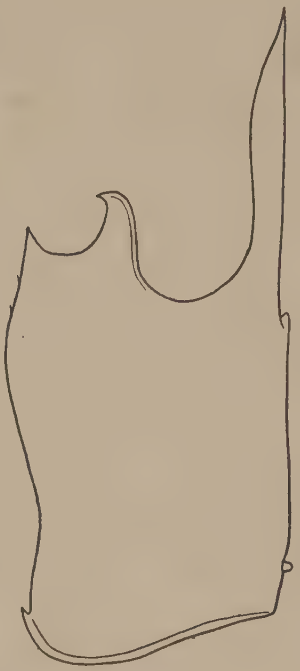

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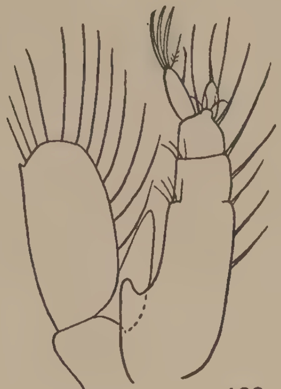

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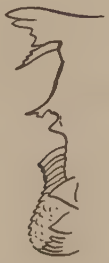


121

Hippolytid R.S. I.

Fig. 118. Stage III, dorsal.

Fig. 119. Stage III, carapace.

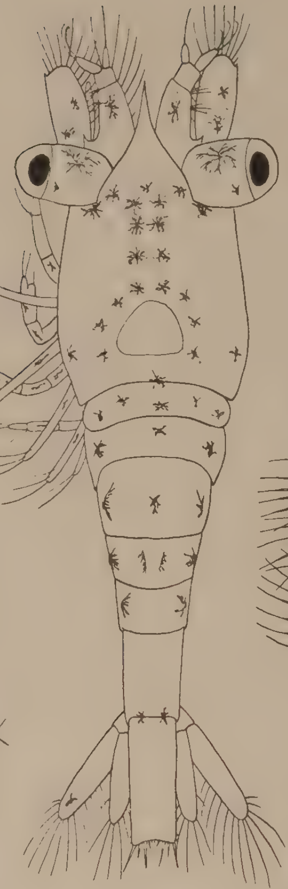
Fig. 120. Stage III, antennae.

Fig. 121. Stage III, mandible, left side.

This stage was observed to arise by moult from stage III and to moult itself to post-larval. Unfortunately this specimen died before the moult was completed, and the legs were not fully freed.

Post-larval Stage I (Figs. 129–133).

Rostrum with three large ventral teeth and six dorsal, of which three are on the carapace; carapace with antennal spine and a group of three small spines at anterior angle, but without supra-orbital. Telson long and narrow, its greatest width a little less



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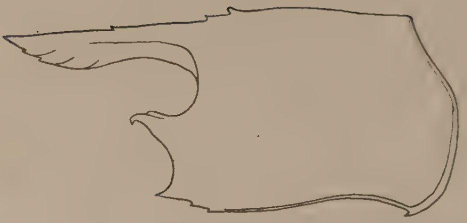

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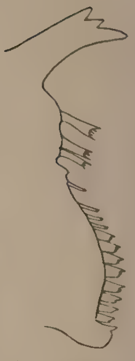

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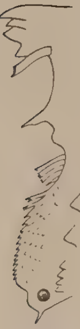

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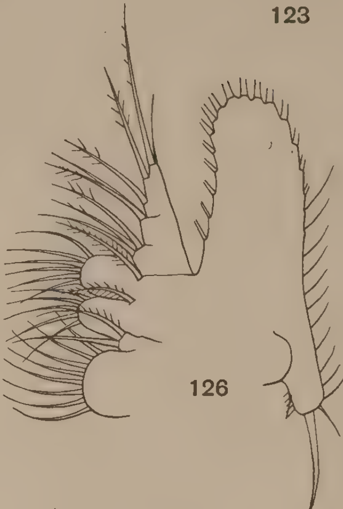

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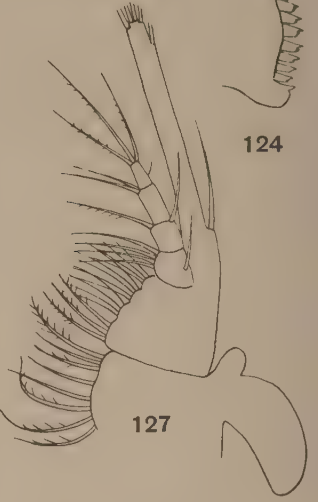

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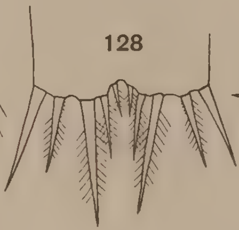

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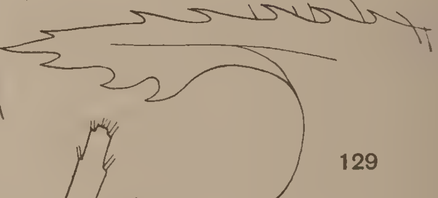

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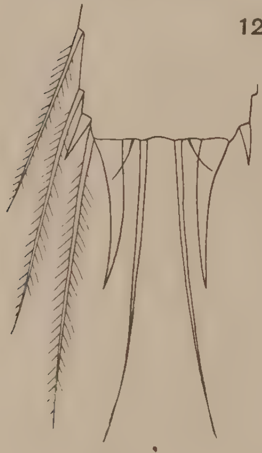

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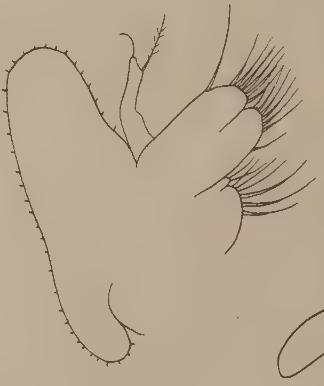

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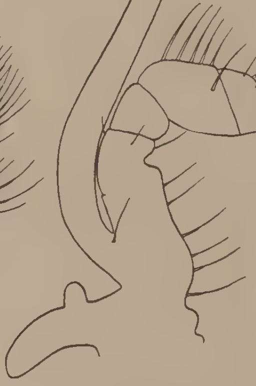

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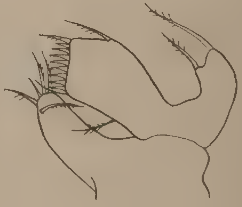


131

Hippolytid R.S. II.

Fig. 122. Stage IV, dorsal (of a species distinct from R.S. II).
Figs. 124, 125. Stage IV, mandible, right and left.
Fig. 127. Stage IV, maxillipede 1.
Fig. 129. Post-larval stage I, rostrum.
Fig. 131. Post-larval stage I, maxillule.
Fig. 133. Post-larval stage I, maxillipede 2.
Fig. 123. Stage IV, carapace.
Fig. 126. Stage IV, maxilla.
Fig. 128. Stage IV, end of telson.
Fig. 130. Post-larval stage I, telson.
Fig. 132. Post-larval stage I, maxilla.

than one-third the length; two pairs of dorso-lateral spines; posterior margin with two pairs of spines, the inner pair very large, and four pairs of long setae, of which the outer three are feathered. Antennule with narrow pointed stylocerite. Antennal scale broad, with outer apical spine. Mandible with incisor process and rudimentary unsegmented palp. Maxillule, proximal endite narrow; endopod small, curved, with two setae. Maxilla, endite 1 very much shorter than endites 3 and 4, with a small lobe representing endite 2; proximal setae of exopod not very long; endopod small and slender.

Maxillipede 1, exopod with five setae on basal part, and six distal; coxa and basis large; epipod large, with small anterior lobe like a rudimentary podobranch. Epipod of maxillipede 2 as that of maxillipede 1, with anterior lobe representing a podobranch. Exopod of maxillipede 3 large, with six setae. Small epipods present on legs 1–4, but no trace of arthrobranchs. Legs 1 and 2 not free from moult, but carpus of leg 2 distinctly divided into three segments, segments 1 and 3 very much smaller than 2.

Although this specimen is not perfect most of the characters of systematic importance can be established; but it cannot be definitely stated that the carpus of leg 2 shows the final segmentation; or that the arthrobranchs may not appear in later stages. Judging by the development of *Spirontocaris cranchii* and *S. occulta* (Lebour, 1936) one would expect the carpus to be divided from the first to the full, or nearly the full, number of segments found in the adult, and it is improbable that there would be no trace of arthrobranchs, if the adult possesses them. According to the keys to the genera of Hippolytidae given by Calman (1906) and Kemp (1914) the combination of characters found in this species is not found in any known genus. The larvae are so exactly like those of *Saron* that there cannot be a doubt that they belong to a genus related to it; but no such genus is known which lacks arthrobranchs. The resemblance to the larvae of *Latreutes* is rather close, but *Latreutes* and its allies have a mandible without palp or incisor process. The lack of a palp is not a character of much importance, since in the two very closely allied species *Spirontocaris cranchii* and *S. occulta* (Lebour, 1936) the latter has a palp while the former has not; but the absence or presence of an incisor process seems to be a character of primary value.

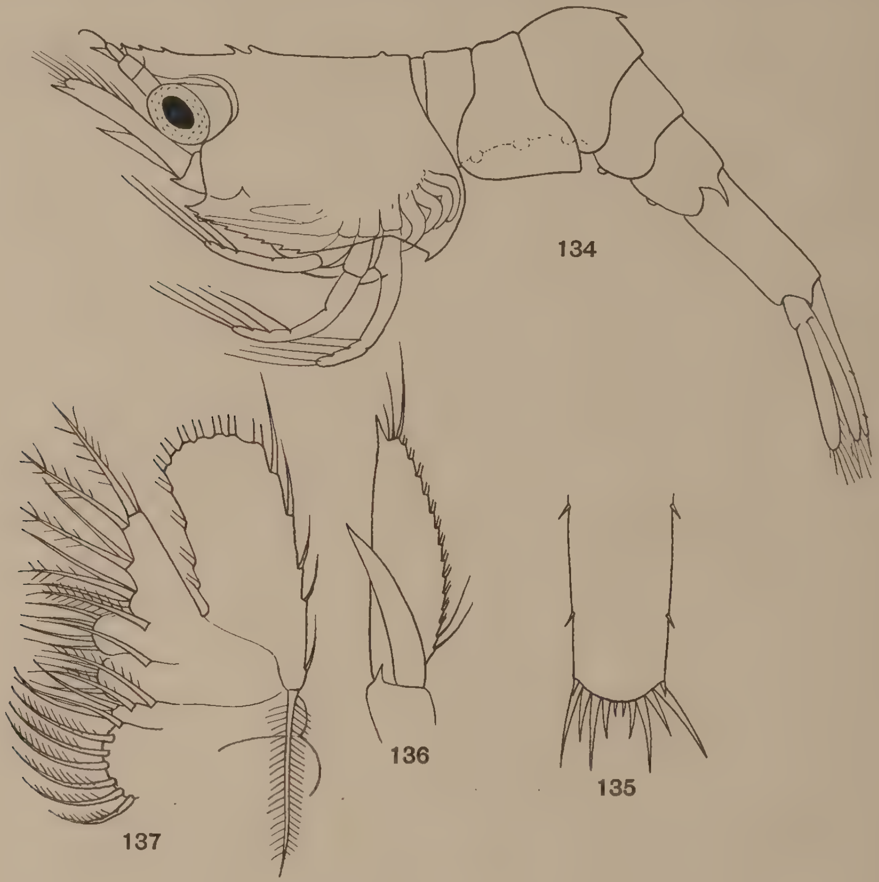
One point is of rather special interest in this developmental series, namely the small number of stages. In most Hippolytidae known there are as many as nine stages (Lebour, 1936, p. 99), but these may be greatly abbreviated as shown above for *Chorismus* which has three only. In the present form there are only four, but stage I is a perfectly normal larva with quite small rudiments of the legs. In *Hippolyte proteus* there appear to be four stages (Gurney, 1927) instead of the nine which Miss Lebour has found in *H. varians*.

A total number of nine stages is found commonly among Caridea, and is not known to be exceeded. It is interesting to note that both Fraser and John in their admirable accounts of the development of Euphausidae (1936) agree in finding three *Calyptopis* and six (or rarely seven) *Furcilia* stages, the term *Furcilia* being used to include all stages between *Calyptopis* and post-larval. Accepting, then, the interpretation of stages 1–3 of Caridea as equivalent to the *Protozoea* of Penaeidea and the *Calyptopis* of Euphausidae (Gurney, 1926), the total number of possible stages in Caridea is precisely the same as it is in Euphausidae.

LATREUTES MUCRONATUS (STIMPSON)?

STAGE IV. Length 3·9 mm. (Figs. 134–137).

Rostrum longer than antennule, with three dorsal teeth; carapace with tooth in front of anterior dorsal papilla; ventral margin with a series of small anterior teeth and conspicuous posterior tooth. Pleura of abdominal somite 2 very large, pointed behind; somite 3 with small median dorsal spine; somite 5 with large lateral spines. Telson four times as long as wide, with two pairs of lateral spines and 6 + 6 terminal spines. Anal spine present.



Latreutes mucronatus?

Fig. 134. Stage IV. Fig. 135. Telson. Fig. 136. Antenna. Fig. 137. Maxilla.

Antennal scale narrowing towards end, with large apical spine; endopod short and stout. Maxilla, exopod very broad in front, with very large proximal seta.

Maxillipede 1 coxa large; epipod large; exopod with five setae. Maxillipede 3 with ten setae on exopod.

Leg 1 endopod short, not distinctly segmented, with incipient chela; exopod with ten setae. Leg 2 endopod rudimentary, bifid at end. Legs 3–5 rudimentary. No rudiments of exopods seen on legs 2–5. Four large rudiments of pleurobranchs on legs 1–4 and very small one on leg 5; no epipods.

Pleopods present as small buds. Uropods with numerous setae on both branches.

One specimen of this form was found in plankton from Barrier Reef St. 1. A young specimen, perhaps in post-larval stage 2, St. 65 is recognizable as belonging to *L. mucronatus*. The larva almost certainly belongs to the genus *Latreutes*, and it is a fair speculation to refer it a species which was also taken in plankton in much the same locality.

DISCUSSION AND SUMMARY OF GENERIC CHARACTERS

The general characters of the Hippolytid larvae then known were summarized by Miss Lebour (1932), and I give an extended summary below. It must be confessed that they do not throw any clear light upon the systematic grouping of the Hippolytidae, though they suggest that the separation of a Latreutid group is not justified. As Miss Lebour has said, the characters of the larvae point to a division into new families or subfamilies, but our knowledge is not sufficiently complete to carry the suggestion farther. It is peculiarly disappointing that I am unable to determine the parentage of the remarkable group of larvae from the Red Sea, since the characters of *Saron* and *Latreutes* are left uncertain. Before any definite conclusions can be put forward it is necessary not only to know more about these two genera, but also the development of *Thor*, which, on adult structure, seems to be inseparable from *Spirontocaris* (Lebour, 1936).

The larval characters of the Hippolytidae, so far as they are known, may be summarized thus:

Hippolyte

Rostrum present in stage I, remaining simple, broad at base.

Carapace without supra-orbital spines, or with very small spines in late stages; margin denticulate.

Abdominal somite 5 with dorso-lateral spines.

Telson broad in early stages, and later with two pairs of lateral spines and twelve terminal.

Anal spine present in late stages.

Antennal scale with tendency to lose segmentation; endopod spine-like in stages I and II.

Maxillule with outer seta.

Exopods of maxillipede 3 with three terminal setae in stage I.

Exopods on legs 1 and 2 only; legs 3–5 remaining apparently non-functional.

From four to nine larval stages.

Chorismus

Rostrum long and rather stout.

Carapace with supra-orbital spines; margin smooth.

Abdominal somites without spines.

Telson broad, with twenty spines in stage I.

Anal spine present.

Antennal scale segmented, with one outer seta; endopod a long flagellum in stage I.

Maxillule without outer seta.

Exopod of maxillipede 3 with three apical setae in stage I.

Exopods on legs 1–3.

Development greatly abbreviated.

Spirontocaris

Rostrum absent in stage I (except in *S. spinus*), remaining very short and broad.

Carapace with small supra-orbital spines and denticulate margin.

Abdominal somite 5 with or without dorso-lateral spines.

Telson rather deeply indented, in late stages with two pairs of lateral spines and twelve terminal.

Anal spine present from stage I.

Antennal scale segmented, endopod spine-like.

Maxillule without outer seta.

Exopod of maxillipede 3 with three terminal setae in stage 1.

Exopods on 2, 3 or 4 pairs of legs.

Legs 3–5 long, slender, functional.

Development in four species greatly abbreviated.

Caridion

Rostrum present in stage I; becoming long and slender.

Supra-orbital spines present; margin of carapace denticulate.

Abdominal somite 5 with dorso-lateral spines.

Telson very deeply indented; with two pairs of lateral spines and twelve terminal in late stages.

Anal spine present in late stages.

Antennal scale segmented; endopod a rod with two terminal setae in stages I and II.

Exopod of maxillipede 3 with three terminal setae in stage I.

Exopods on legs 1–4.

Legs 3–5 very long and slender, propodus sometimes expanded slightly.

Nine larval stages.

Lysmata and Hippolysmata

Rostrum long and slender in stage I.

Carapace with supra-orbital spines and denticulate margin.

Abdominal somite 5 with or without dorso-lateral spines.

Telson deeply indented; in late stages with two pairs of lateral spines and ten terminal.

Anal spine absent.

Eyes borne upon long stalks.

Antennal scale segmented; endopod a rod with one seta.

Maxillule without outer seta.

Exopod of maxillipede 3 with three terminal setae in stage I.

Exopods on legs 1–4.

Leg 5 appearing before leg 4 and of enormous size; with propod greatly expanded.

Probably nine larval stages.

Tozeuma

Rostrum of extreme length.

Supra-orbital spines very small; margin of carapace smooth.

Abdominal somite 3 with large dorsal spine; somite 5 with lateral spines.

Telson deeply indented, becoming forked, with three outer spines and ten terminal of which one forms the point of the fork.

Anal spine absent, or present in late stages.

Antennal scale slightly segmented; endopod spine-like.

Maxillule without outer seta.

Exopod of maxillipede 3 with three terminal setae in stage I.

Exopods on legs 1–3.

Probably nine larval stages.

Saron (and allied forms)

Body stout, very highly coloured.

Rostrum present or absent in stage I; later stout, and broad at base.

Carapace without supra-orbital spines; anterior margin denticulate; with posterior tooth.

Abdominal somites without spines.

Telson narrow in stages I and II, scarcely indented; later without lateral spines and with ten terminal spines.

Anal spine absent.

Antennal scale segmented; endopod spine-like.

Exopod of maxillipede 3 with four apical setae.

Exopods on legs 1–4.

Number of larval stages uncertain. Reduced to four in one species.

Latreutes (stage I only)

Rostrum small.

Carapace with strong pterygostomial and posterior teeth, without anterior marginal teeth. A strong tooth in middle of margin in *L. fucorum*.

Abdominal somite 5 with large dorso-lateral spines; spines also on somite 4 in *L. fucorum*.

Telson very narrow.

Antennal scale with segmentation almost lost; endopod spine-like, but with a seta also.

Maxillule without outer seta.

Exopod of maxillipede 3 with four apical setae.

(No later stages known with certainty.)

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